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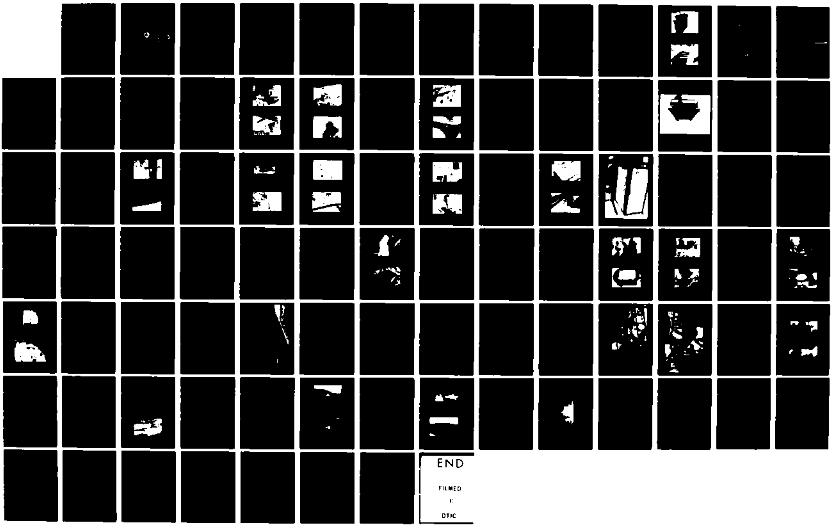

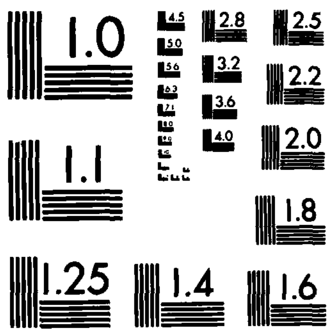

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Report No. CG-D-46-82

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A COMPARATIVE EVALUATION OF THREE POTENTIAL ICE RESCUE VEHICLES

BY: LTJG JOHN A. BUDDE, USCGR

SEPTEMBER 1982

FINAL REPORT

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16. Abstract This report presents the results of tests conducted on the Great Lakes during the 1982 winter season. Three vehicles were evaluated as potential replacements for the traditional method of dragging a 14-foot ice skiff by hand across the ice. Two of the craft, the all terrain vehicle (ATV) and the airboat, were subjects of preliminary testing during 1981. Preliminary tests of the air cushion vehicle (ACV) were conducted in Detroit, Michigan in January of 1982. The ACV proved to be unsuitable as an ice rescue platform because of its low payload capability, restricted maneuverability, and susceptibility to skirt system damage. The ATV and airboat were tested together, in side-by-side trials, at Marblehead, Ohio, on Lake Erie, in January of 1982. Based on these trials, this report recommends that the airboat be selected for inclusion in the Coast Guard inventory as the surface ice rescue vehicle.

17. Key Words Ice rescue, airboat, air cushion vehicle (ACV), All terrain vehicle (ATV).		18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22151	
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METRIC CONVERSION FACTORS

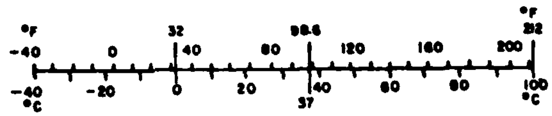
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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Introduction

This report details the preliminary testing of the air-cushion vehicle and the side-by-side trials of the airboat and all terrain vehicle held in Marblehead, Ohio on Lake Erie during January of 1982. During the winter of 1982, three different types of vehicles were tested on the Great Lakes for possible use by the United States Coast Guard as ice rescue platforms. The trials covered in this report are a continuation of work begun the previous year by personnel of the Ninth Coast Guard District, with headquarters in Cleveland, Ohio. In order to identify a safer, more efficient means of conducting search and rescue operations on the Great Lakes during the winter months, personnel from Coast Guard Station Marblehead, Ohio and Coast Guard Station Saginaw, Michigan began testing an all terrain vehicle (ATV) and a modified airboat during the winter of 1981. This was to be a formal evaluation with a preliminary report presented to the Chief of the Search and Rescue Branch for the Ninth District in the spring. The result of these tests (1, 2) prompted the decision to continue the tests into the 1982 winter season and to begin the evaluation of a small air cushion vehicle. It was also decided to hold side-by-side trials of all three vehicles during the early winter months.

1.1 Background

The United States Coast Guard has the primary responsibility for conducting search and rescue operations on the Great Lakes. In order to

carry out this responsibility, shore stations with rescue response capabilities are maintained along the coastline of each lake. Each station is responsible for responding to all calls for assistance in a defined area. The number of cases answered in a given year will vary from station to station depending upon the volume of waterborne commerce and recreational activity in the area. Some stations such as Marblehead, Ohio will respond to as many as a thousand cases in a single year. During the 1980 SAR season, Station Marblehead answered 1,273 cases. This represented an increase of 16.5% over the previous year. The number of cases handled by these stations is increasing annually and is expected to continue to do so.

The great majority of cases are handled in the summer months when recreational water activities peak. At Marblehead, the largest number of calls are received during the peak Walleye fishing season. Some cases, however, do occur during the winter months. Traditional winter activities such as ice fishing and hiking on the ice remain popular and, in recent years, snowmobiling on the frozen lakes has greatly increased.

First ice will usually be seen in the lower lakes in December. Ice coverage reaches its maximum throughout the lakes with Lake Erie recording up to seven and occasionally eight oktas, by March. The ice in the lakes is subject to great stress. The ice is continually being moved by the wind. Pressure ridging is obvious near the shoreline and may reach heights of up to four feet. The ice is unstable and may suddenly break up creating flows within the lakes. Gaps in the ice of several hundred yards may appear in a

relatively short period of time. Great Lakes winter navigation also stresses the ice when channels are cut by and for ore carriers.

The number of people on the ice at any given time is dependent on several factors. The two major factors are the activity in question and the predominate weather. Snowmobilers may ride either alone or in groups, and ice fishermen may be present in small quantities or in groups which number in the hundreds. Figure 1.1 is an aerial photograph of Lake Erie taken near Marblehead, Ohio. Each of the small black dots in the photograph is an ice shanty. Fishermen cut holes in the ice with awls and then move these shanties by means of runners directly over them. Although comfortable for the fishermen, these shanties can create problems. The individual inside may not be aware of the fact that the portion of ice he is situated on has broken loose and is now several hundred yards from shore. The ice shanties may also cause problems because of shear numbers. When an individual is reported missing or overdue, it may take hours to inspect each shanty in the search area. During the winter of 1980, one case involved the rescue of approximately one hundred people from an ice shelf the size of a football field. Using helicopters and ice skiffs, Coastguardsmen and volunteer firemen from Lakeside, Ohio were able to successfully extract all of the victims and to transport them to safety.

1.2 Current Rescue Methods

Since its introduction, the helicopter has been and will probably continue to be the primary method of conducting ice rescues. The helicopter

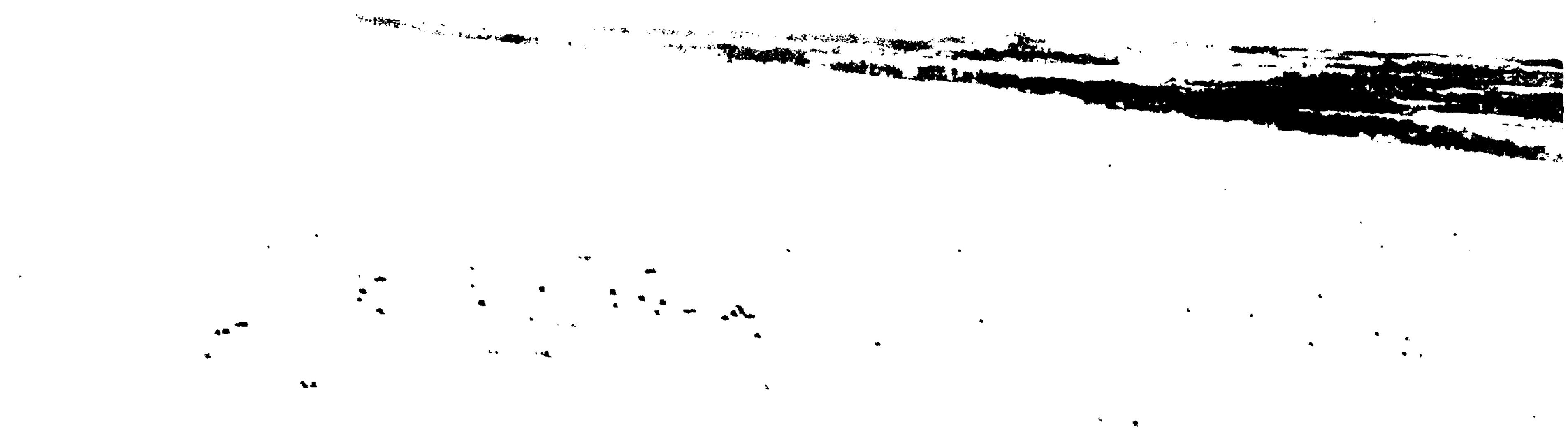


Figure [illegible] An aerial view of Lake Erie, near Marblehead, Ohio. The black dots on the ice are shanties erected by ice-fishermen.

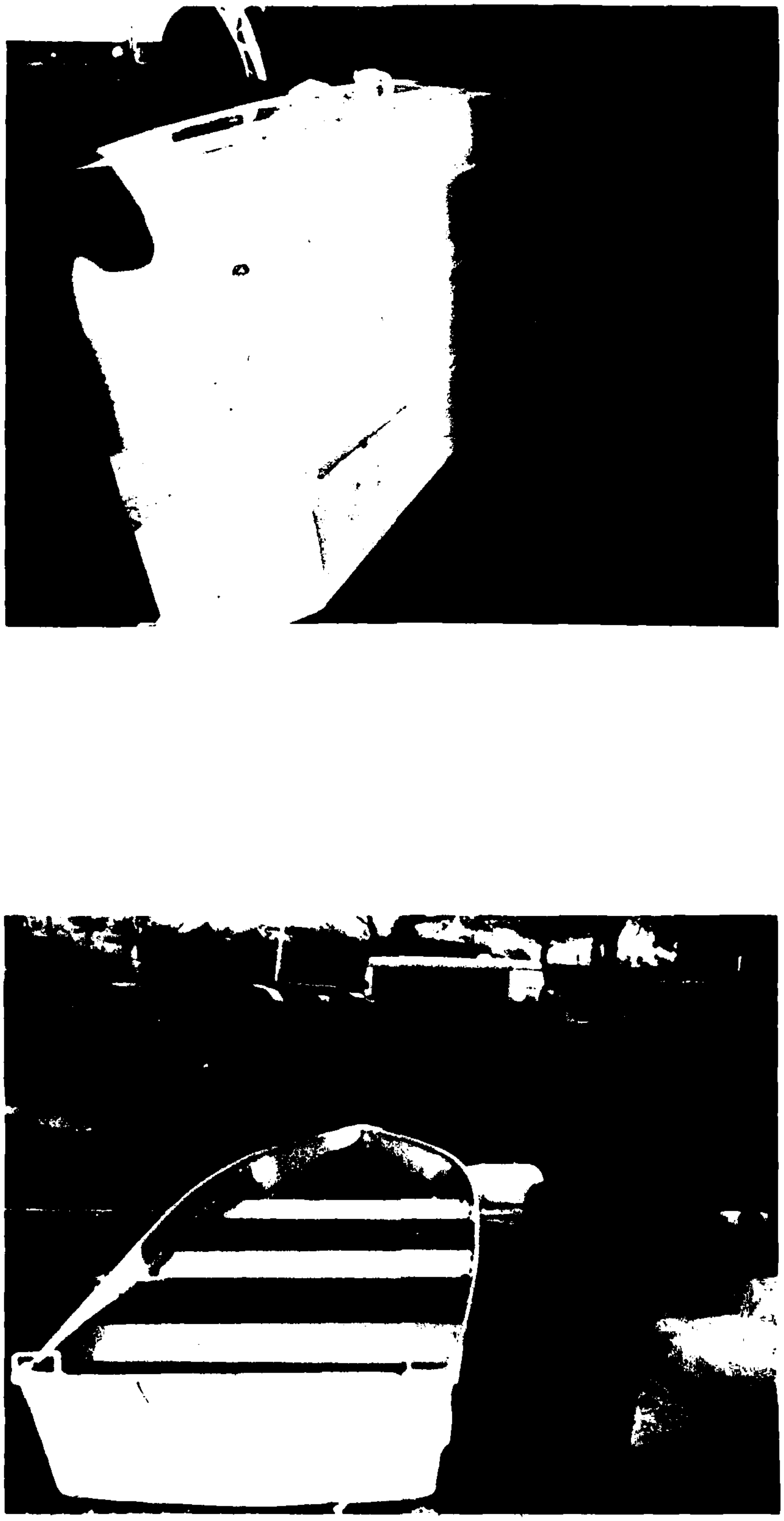


Figure 1.2 (a and b) Two vie[illegible] a [illegible]ast Guard 14- Foot, aluminum ice skiff.

Figure 1.3 (a and b) Two views showing the current method of dragging a skiff across the ice. Two :rewmembers are harnessed to the front of the skiff to pull it, while a third crewmember pushes from behind the transom.

Figure 1.4 A photograph of pressure ridging on Lake Erie. The photograph was taken within a mile of Station Marblehead, Ohio in January 1982.

has the capability to respond quickly and to extract a victim while placing the crew at minimum risk. The victim may be transported to medical facilities quickly and, if necessary, emergency medical procedures may be begun in the craft. There are times, however, when the weather is below minimums and a helicopter cannot be dispatched. It is during these periods that alternate rescue platforms must be utilized.

The current method of conducting searches and rescues on the ice is to use a fourteen foot aluminum ice skiff. The skiff is actually a fourteen foot aluminum boat which is dragged across the ice (Figure 1.2). Two coastguardsmen are harnessed to the bow of the craft and pull it while a third pushes from behind (Figures 1.3). The traditional dress is wet suits and boots with ice cleats. The method is arduous and the crewmen become fatigued very rapidly. The wet suits do not provide adequate protection against the cold winds, especially when wet, and consequently the crewmembers performance is degraded very quickly.

The craft must be pulled and pushed over the pressure ridges (Figure 1.4) which may extend for hundreds of yards. When open water is encountered, the boat must be launched, then piloted to the other side. When the victim's location is reached, the procedure is reversed with the victim wrapped in blankets and secured in the skiff. A rescue may be accomplished quickly if the skiff can be maneuvered by vehicle and trailer to a launch site near the victim's location. A case involving a large search area may take up to several hours and may have to be conducted in

precipitation and sub-freezing temperatures. The crewmembers involved in the operation are themselves at risk. It is for this reason that an effort was made to find a more adequate rescue platform.

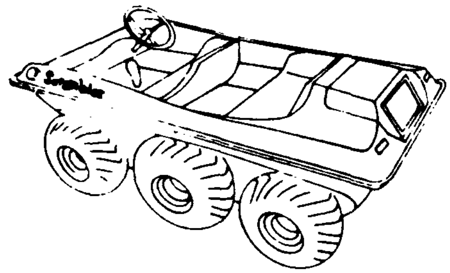
The Coast Guard sought to find vehicles which would provide increased crewmember and survivor protection while at the same time providing increased speed, safety of operation, and reliability of equipment and communications. Appendix C is a list of operating restrictions for Coast Guard Group Detroit and is applicable to all of the Coast Guard ice rescue vehicles tested. The list was promulgated by Commanding Officer, Coast Guard Group Detroit.

2.0 All Terrain Vehicle (ATV) Evaluation

The all terrain vehicle (ATV) was given a preliminary evaluation at Coast Guard Station Marblehead, Ohio during the winter of 1981. Under the direction of the station Commanding Officer, the crew underwent familiarization with the vehicle and various operating concepts were evaluated. Coxswains and engineers were qualified during this period and recommendations were made on the use of this vehicle as an ice rescue platform. A description of the craft and a discussion of preliminary findings, taken from the All Terrain Vehicle (ATV) Evaluation/Performance Log (1) are given in the following sections.

Scrambler

SPECIFICATIONS



SCRAMBLER 6

No. of Wheels: 6

Body: Fiberglass

Length: 94"

Width: 54"

Weight: 640 lbs./3-seater   680 lbs./4-seater

Max. Load: 900 lbs.

Tire Size: 21 x 12-8

Steering System: Hydraulic braking (available in stick or wheel)

Engine: American made, Tecumseh-engine, single cylinder, overhead valve, 4 cycle, 454 cc

Engine H.P.: 16

Type of Fuel: Regular gas

Ignition: Solid State

Charging System: 20 Ampere hours

Transmission: Torque sensitive, centrifugal clutch

Final Drive: Chain

Cruising Speed: Land - 35 m.p.h.   Water - 4 m.p.h.

Figure 2.1 The technical data sheet for the Scrambler all terrain vehicle obtained from the manufacturers brochure. Weight for the four man model does not include roll bar, canopy and other Forester 4000 accessories.

2.1 Description of the ATV

The vehicle chosen for the evaluation was a small, fiberglass ATV manufactured by the Scrambler Corporation, Genoa, Ohio. Figure 2.1 is the manufacturer's specification sheet for the ATV. The specific model chosen was the Forrester #4000. Figure 2.2 is a photograph of the vehicle as it was configured for the tests.

The Scrambler is an open, fiberglass, ATV which seats four persons rather uncomfortably. The rear seat is small, with very little leg room. For comfort and added safety, a canopy top and roll bar have been fitted to the ATV (Figure 2.3). Communications are maintained by a Triton VHF, FM radio. Because of limited space in the front seat area, the radio had to be mounted on the rear of the front seat (Figure 2.4).

Power for the vehicle is provided by a 16 h.p., 454 cc, air cooled, Tecumseh 4-cycle engine (Figure 2.5). A chain drive system is employed for forward motion but reverse gear is electrical. A heavy duty 12 volt battery supplies electrical power for the electric start, reverse gear, radio, and winch. Instrumentation includes a battery indicator and meter. The ATV is equipped with headlights (visible in Figure 2.9).

Two sets of tires and a pair of "Tuff Tracks" were purchased with the vehicle. The Scrambler is a six-wheeled vehicle which can be operated in a variety of terrains including pavement, sand, grass, mud, ice, and water.

Figure 2.2 The All Terrain Vehicle (ATV) as it was configured for the tests.

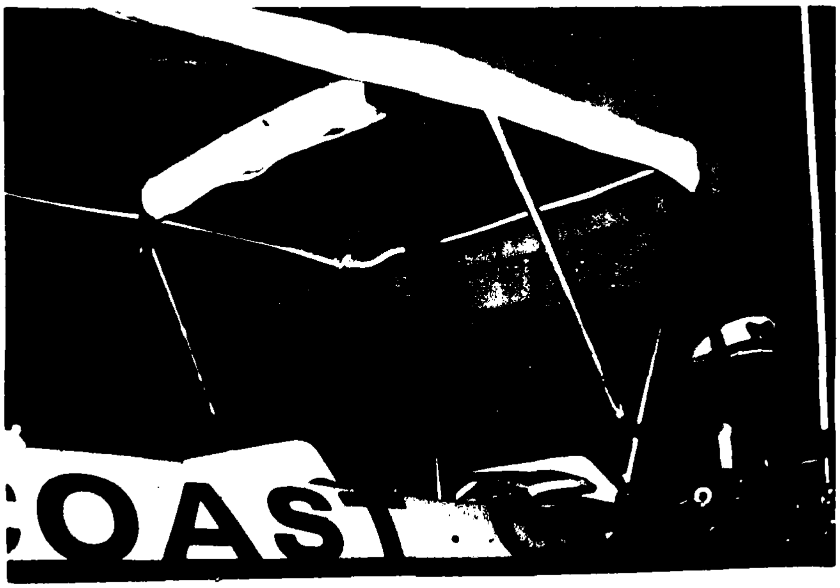


Figure 2.3 The roll bar and canopy top are shown in the photo above.

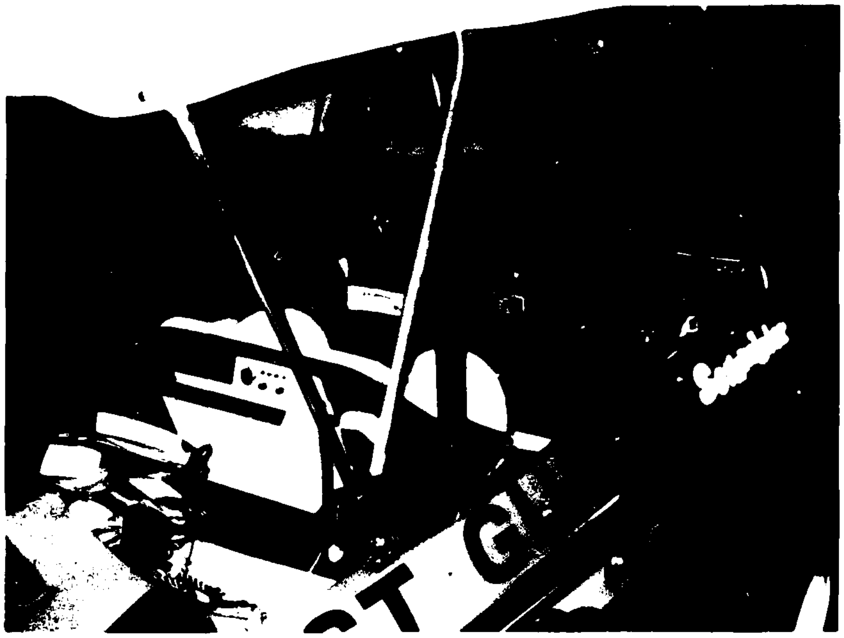


Figure 2.4 A photograph of the interior of the ATV showing limited space and the position of the Triton radio.

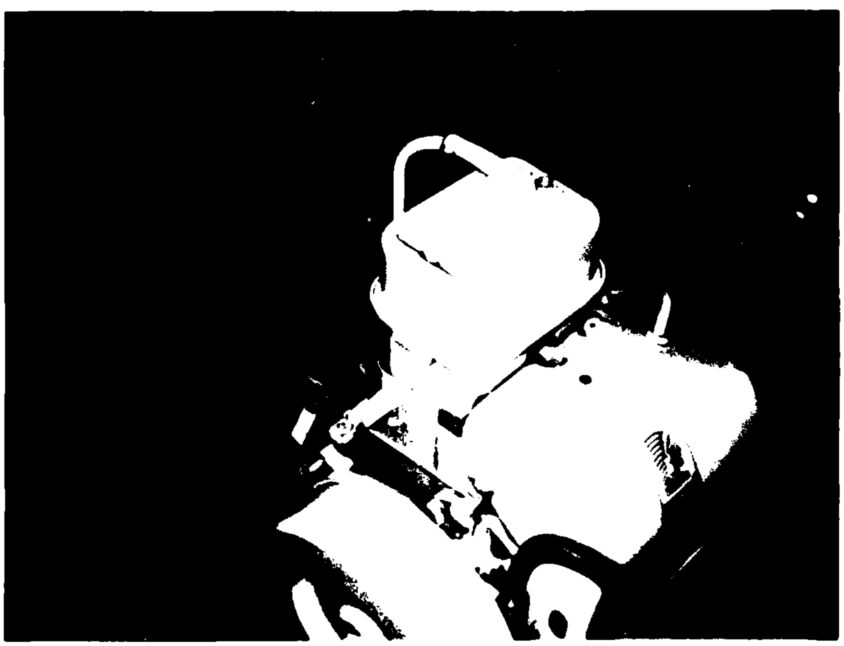


Figure 2.5 The Tecumseh, 454 cc., air cooled engine.

Six rubber Carlisle tires and six studded rawhide tires can be interchanged to suit the operating environment. The rawhide tires are used for ice operations (Figure 2.6). The "Tuff Treads" are not utilized by the station. The ATV is capable of attaining speeds of up to 35 mph on land (manufacturer's information).

Auxiliary equipment includes a bilge pump in case water is shipped into the ATV, and a transport trailer (Visible in Figure 2.2). The total weight of the ATV is 780 lbs; the trailer is 300 lbs., and the combined helicopter lifting weight is 1080 lbs. Helicopter lifting eyes have been installed at each of the four corners of the ATV (Figure 2.7).

Both propulsion and flotation are provided by the six tires. This accounts for the slowness of the craft when underway in the water-4mph. The lack of additional flotation is cause for some concern. In January of 1982 a small ATV (manufacturer and model unknown) broke through the ice while operating on frozen Lake St. Clair. The craft was holed after repeated rammings of the ice edge in an attempt to climb out. The operator, in this case, had no trouble climbing out of the craft to safety, but the ATV, itself, sank and was not recovered. This potential problem could be overcome by the addition of foam flotation material.

2.2 Preliminary Evaluation of the ATV

The Scrambler ATV received a preliminary evaluation as an ice rescue platform during the winter of 1981. The test was conducted at Marblehead,

Figure 2.6 Side view of the ATV showing the studded, rawhide tires.

Figure 2.7 Helicopter lifting eyes were installed at each of the four corners of the ATV.

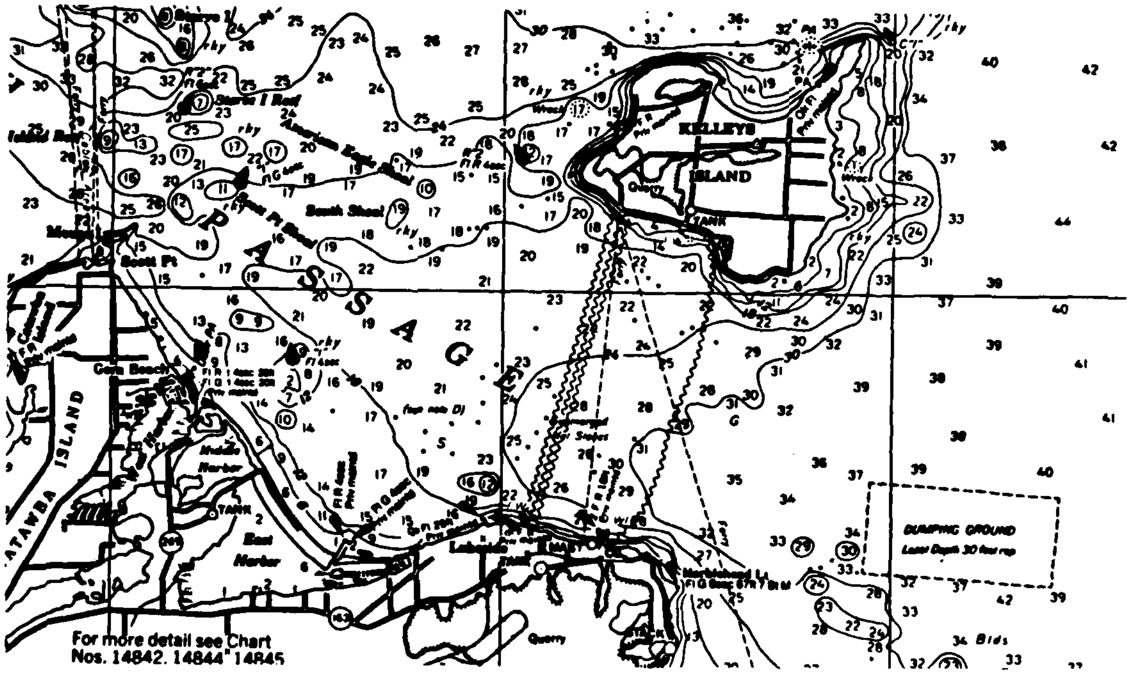


Figure 2.3 The ATV and Side-by-Side Trials were held on Lake Erie between Marblehead Coast Guard Station and Kelleys Island.

Ohio on Lake Erie (Figure 2.8). The vehicle was received by the station on January 22, 1981. Scrambler Corporation representatives gave an introduction and operating instructions to the personnel of CG Station Marblehead. The crew then began familiarization and training with the craft and experimenting with operational procedures.

The ATV is capable of maintaining a top speed on the ice of 20-25 mph, except when transiting windrows (pressure ridges). A trained operator can pick his way through the windrows quickly, but at reduced speed. The coxswain maneuvers the ATV within the windrows until he finds a suitable spot and then simply drives up and over. The vehicle is stable but should be operated with caution in the windrows. Excessive speed results in an extremely bumpy ride. Crew members are required to wear helmets when operating the craft (1). Sudden impacts and jolts are common when operating in the windrows and crew members can be pitched forward suddenly into the windscreen.

The craft was operated on open water during the evaluation. Speeds of from 2 1/2 - 4 mph were obtained while operating in wave heights of approximately 6 inches with 20-25 knot winds. There is a noticeable sail effect due to the shape of the craft and the fact that it rides high in the water. It requires a skilled operator to maneuver under these conditions (1).

The main problem with in-water operations is the inability of the ATV to climb out of the water back on to the ice. The ATV hull contacts the ice edge first, stopping all forward advance (1). Repeated, full speed rammings of the ice were tried, but station personnel were never able to climb out of the water without assistance. This problem has been overcome, however, by the installation of an electric winch on the front of the craft (Figure 2.9). A crewman steps out onto the ice and secures the winch line to spikes driven into the ice. The craft is then winched up on to the ice with a full power assist from the ATV. The procedure appears safe and efficient and can be accomplished in approximately one minute. Care must be taken to ensure that the cable does not slip off the drum (1).

It was discovered, that with a person sitting in the back seat, the ATV comes up at angle of about 25^{o} when it engages the ice. This causes the craft to ship water into the engine compartment through the ventilation louvers. The bilge pump effectively removes most of the water but leaves approximately 1-2 quarts in the compartment. It is felt that this problem can be corrected by experimenting with various locations for the pump and relocating it accordingly (1). In order to remove the excess water, the vehicle front end had to be lifted 10^{o}.

Another limitation of the craft is its size. The rear seat, although rated for two people, is small and can only accommodate one person in winter clothing. Leg room is further reduced by the installation of a Triton radio on the back of the front seat. An injured person could not be placed in a

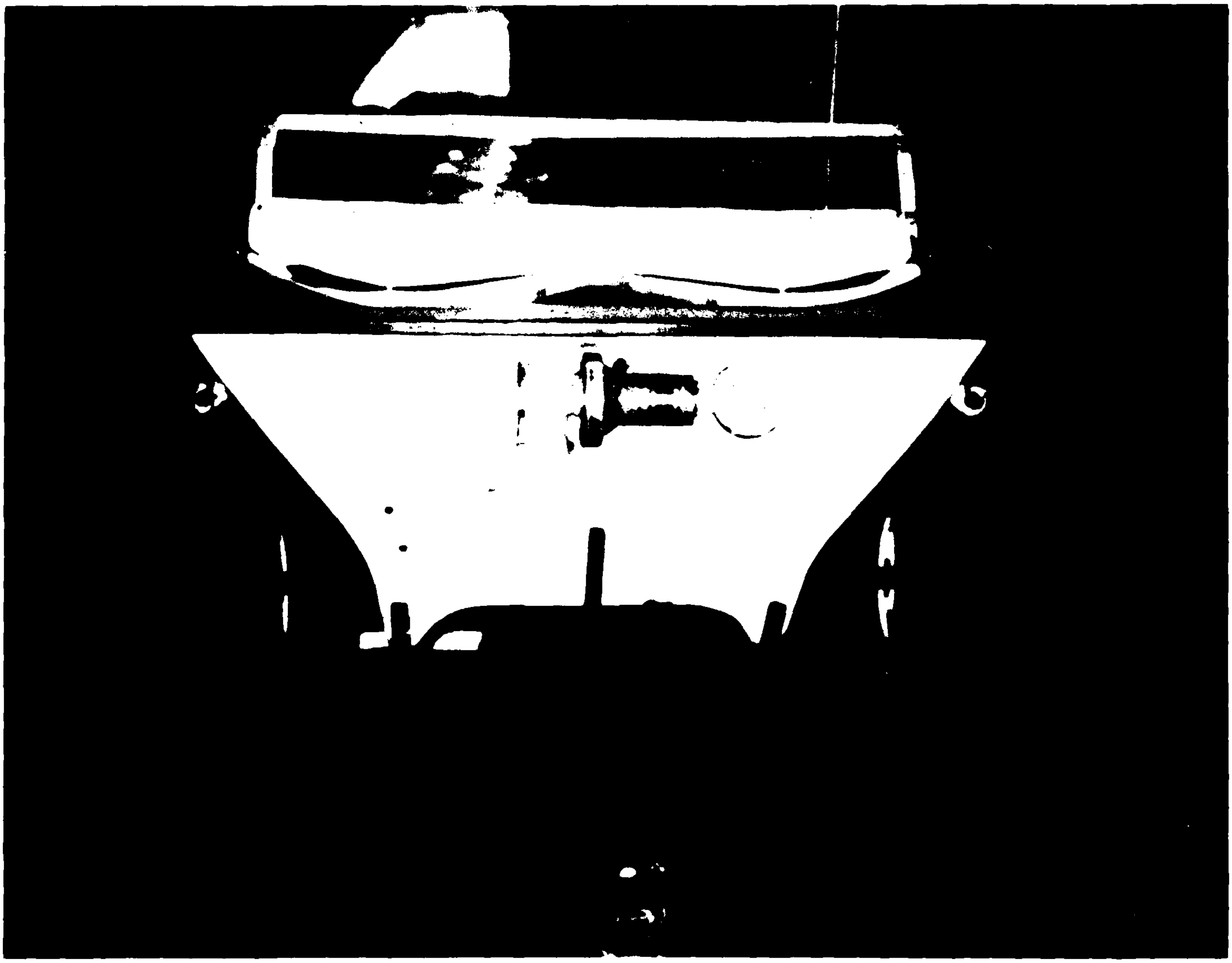


Figure 2.9 The electric winch was mounted to the vehicle front end. The two headlights are also visible in the photograph.

recumbent position in the ATV and there is the additional problem of carrying equipment such as the EMT Kit, blankets, litter (if necessary), etc.

These problems can be overcome by towing the ice-skiff (Figure 1.2). Initially, the ice skiff was attached to the ATV by means of a towline and dragged across the ice in much the same manner as is now done by hand (Section 1.3). This proved impractical, however, due to damage caused to the skiff and the strain on the towline. The problem has been overcome by towing the skiff on its trailer. This reduces the strain on the towline and causes less damage to the skiff. This method has been proven to be a practical and easy solution to the tow problem. It also allows the crew to carry additional rescue equipment and provides a smoother ride for victims. Care must be taken when operating in this manner in the windrows. The trailer can hang up at the top of a windrow necessitating the crew to stop and free it.

Towing the skiff also makes the ATV less maneuverable. The vehicle can operate at full speed while maintaining the tow but care must be taken when executing turns. Turns of over 60° result in the trailer tongue and hoisting winch contacting the stern of the ATV. Although this must be kept in mind when operating with tow to prevent damage to the ATV and/or jackknifing of the trailer, this characteristic is not considered too significant. Sharp turns of 60° or more are not normally required when operating on the ice and if reasonable care is taken, no problems should arise.

One additional problem area should be taken into account. When operating on ice with a surface coating of 1-3 inches of slush and occasional puddles, the crew was subjected to a large amount of spray. The spray was both thrown up from the wheels over the sides of the ATV and over the bow into the front seat area. The crew became thoroughly soaked within minutes. This illustrates the need for good organizational clothing to minimize both the discomfort and danger caused by operating in sub-freezing conditions in wet clothing. Wet suits alone do not provide adequate protection in situations such as this. Station Marblehead, Ohio approached the problem by purchasing water repellant snowmobile suits to be worn over the wet suits. Although practical, this is not the optimium solution. The problem of protective clothing is by no means limited to the ATV. It is a general problem for any ice operation and was encountered to some degree in each of the vehicles tested.

The ATV proved to be a promising candidate for selection as an ice rescue platform. Although it possess certain limitations, it is reliable, it is safe when operated properly, and it greatly improves on the older method of towing and pushing an ice skiff by hand. The decision was made following the review of 1981 operations to continue the evaluation through the 1982 winter season. Appendix A is a list of "Do's and Dont's" compiled by the CO Station Marblehead for crewmen operating the ATV (1). Along with the recommendations and concurrence of the CO Station Marblehead, the Chief, Search and Rescue Branch, CG District Nine issued instructions that the ATV is not to be launched in open water. The ATV and skiff are to be towed to

the launch site nearest the call, then the ATV with skiff in tow will proceed across the ice to the break. The skiff is then launched from the ice edge. Upon its return, it is loaded on its trailer and again taken in tow by the ATV.

3.0 Airboat Preliminary Evaluation

The idea of using an airboat as an ice rescue platform began in the late 1970's with the acquisition of a plastic, aircraft engine powered airboat. This boat proved unsatisfactory due to its fiberglass reinforced plastic hull. The craft was susceptible to damage and the hull had to be replaced annually. A Bew craft, designated as CG-184149, was acquired in 1979 and has been modified to operate as a Coast Guard ice rescue platform. The testing and modification of this craft was carried out by personnel from Coast Guard Station Saginaw River, Michigan and Coast Guard Group Detroit shop personnel under the direction of the Industrial Manager.

3.1 Description of the Airboat (CG-184149)

The craft was originally a stock Panther Airboat Model Eighteen obtained from the Panther Airboat Company. The original craft was powered by a Chevrolet 400 automobile engine. Power is transmitted from the engine by a drive shaft through a reduction gear to a hub and single, wooden, aircraft propeller. Steering is accomplished by means of two rudders mounted aft of

the propeller which divert airflow. (Propeller and rudders are shown in Figure 3.1). There was originally a full 1-1/2 x 3 inch screen surrounding the propeller area.

The hull is an aluminum, flatbottom, airboat hull with hard chines. The overall length of the hull is 18 feet 9 inches and the width at the stern is 8 feet 2 inches (98 inches). The chine width at the stern is 56 inches. Runners have been added to the bottom of the craft. These are aluminum pipes which have been cut in half transversely and welded to the bottom of the craft (Figure 3.2). A single runner is composed of two pipe halves welded parallel to and abutting each other for the length of the craft. The two runners are separated by 44 1/2 inches (Centerline to Centerline) at the stern of the craft. The hull was originally coated with a resin coating known at "steel flex". This coating, applied under the direction of Panther Airboat Company, was designed to protect the hull from abrasion.

The craft as originally configured was a non self-righting open craft. There was no compartmentation or decking and the transverse frames were exposed. The transverse frames were placed on 47 inch centers. There was no bilge pump and the boat plug was located in the stern near the propeller.

The craft had three flotation compartments. Two of the compartments are located aft, one on either side and the third is forward in the bow. The bow compartment forms a small decked area which can be used for minor storage.

Figure 3.1 Wooden Propeller and rudders mounted at the stern of the ATV.

Figure 3.2 Aluminum pipes mounted to the bottom of the craft act as runners.

The operator's seat is positioned on the centerline of the boat and located 6 feet 4 inches forward of the transom. The seat height is 57 inches from the bottom of the boat giving the pilot a clear field of view when operating the craft.

Several substantial modifications were made to the craft during the two seasons it was operated by the crew at Saginaw River prior to the 1982 tests. These will be detailed in the next section.

3.2 CG-184149 Operation and Modification

CG-184149, as it was configured at the beginning of the 1982 winter season, is shown in the photograph in Figure 3.3. As a result of testing by the crew at CG Station Saginaw River, Michigan and actual operations performed with the craft, a number of major modifications were made to the airboat.

During the 1980 season, the original Chevrolet 400 automobile engine failed during normal operations. It was replaced with an eight cylinder Chevrolet 350 automobile engine. The mesh screen as it was originally installed created some problems. The screen is necessary to protect crew members from the rotating propeller but it made even minor repairs difficult without totally removing it. The screen was modified to give easier access to the engine. Its current position and configuration are shown in Figure 3.4 and Figure 3.5). The engine was originally fitted with straight exhaust

Figure 3.3 The Airboat as it was configured for the tests.

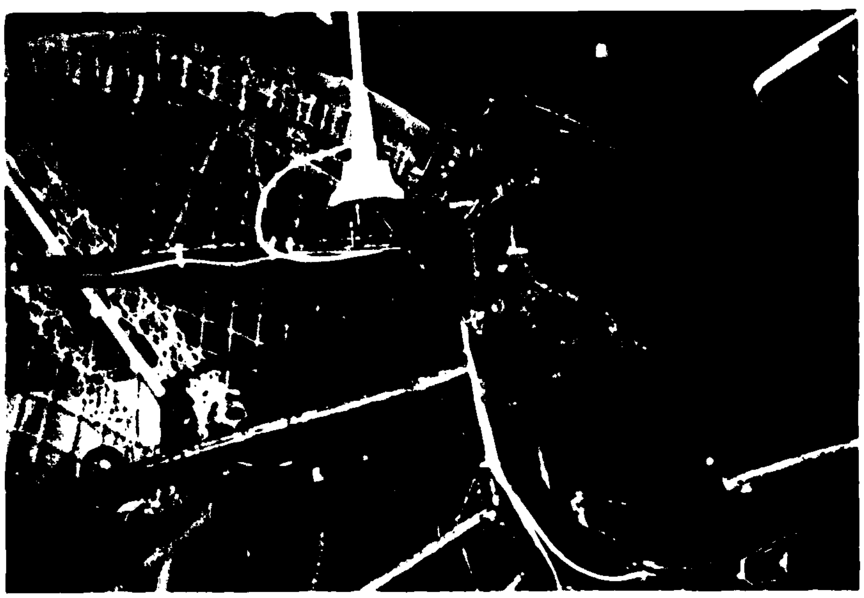


Figure 3.4 The mesh, installed to protect crewmen from the rotating propeller, is shown in the background.

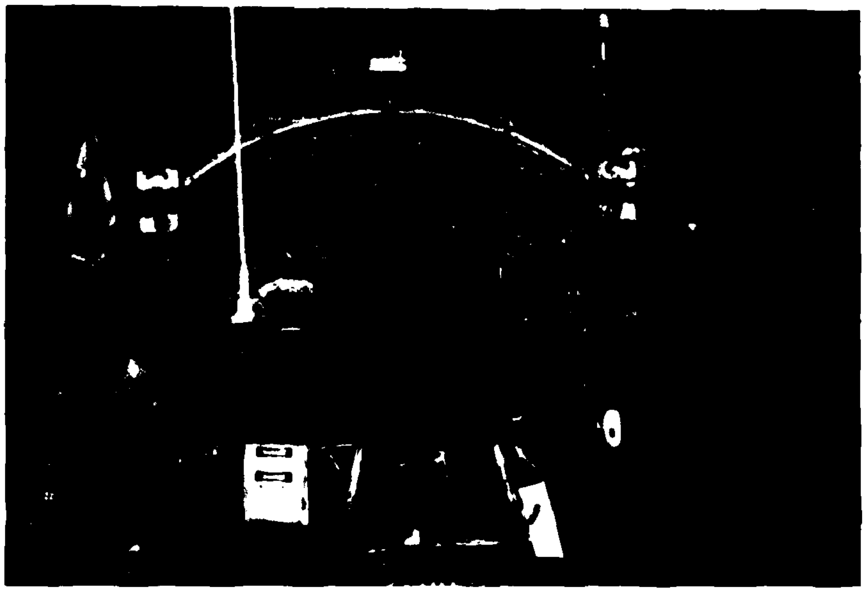


Figure 3.5 The wire screen is shown behind the coxswain's station. The throttle and control stick are visible in the center of the picture.

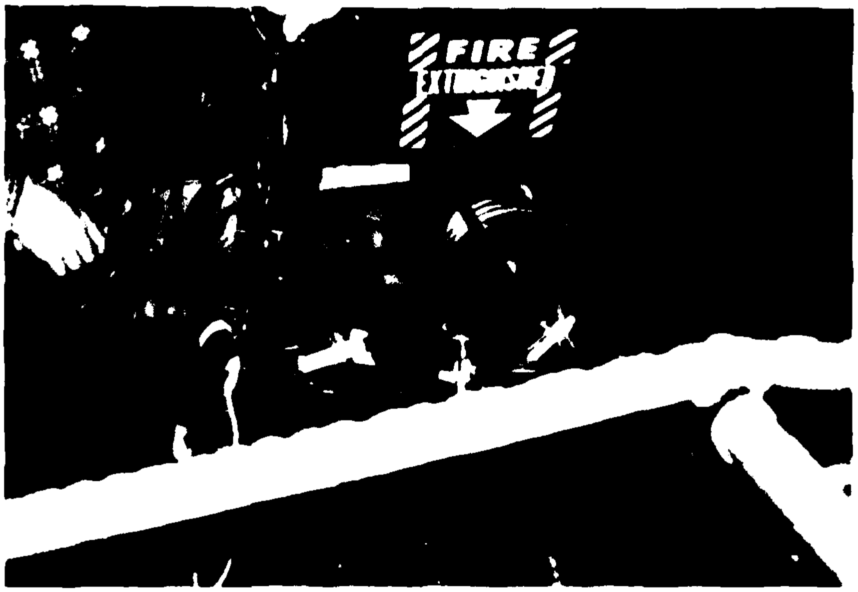


Figure 3.6 The fire extinguisher rack mounted under the coxswains' stand.

pipes. Mufflers were installed to prevent damage to the engine due to operations in frigid, moist air. The addition of mufflers, however, does little to reduce operating noise. The craft is extremely noisy, but most of the noise is from the rotating propeller.

The original one-fuse electrical system was modified to include an electrical console with a multiple fuse system. An emergency, backup battery was installed below the coxswain's seat along with a rack to accommodate three fire extinguishers (Figure 3.6). Two beer kegs were installed aft of the coxswain's stand and are used as gasoline tanks (Figure 3.7). This slightly unorthodox modification seems to have done a great deal for crew morale and does illustrate the enthusiasm and sense of personal pride exhibited by the crew in the development of this craft. Additional fuel is carried in two five gallon cans mounted inside the boat at the stern.

The coxswain station was modified to provide greater safety, comfort, and ease of operation. The original craft had an installed foot throttle. For long operations in severe weather, this proved to be unsatisfactory. The coxswain became fatigued from trying to brace himself in the chair and at the same time maneuver the craft and operate the throttle. Arm rests were provided for the coxswain and a hand operated throttle was positioned

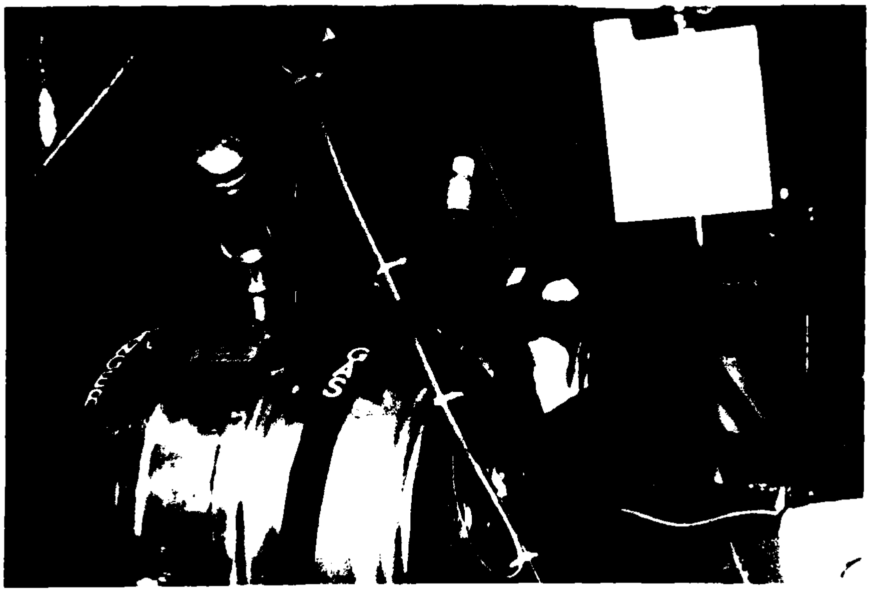


Figure 3.7 Beer keg fuel tanks mounted just aft of the coxswains' stand.

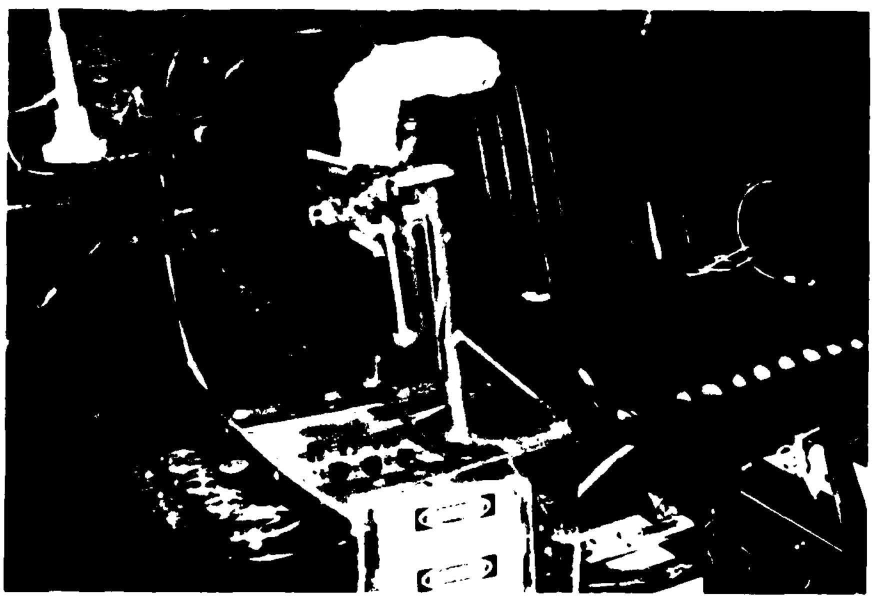


Figure 3.8 A spring loaded, "dead-man" throttle was mounted to the right side of the coxswains' chair.

on the right side of the seat. This is a spring-loaded "dead man" throttle which automatically cuts off when pressure is released (Figure 3.8). Steering is accomplished by operating the single control stick with the left hand. The coxswain's foot rest was angled up at 45° to make it easier for him to brace himself.

The original 1/2 inch aluminum hull was easily damaged and was replaced by a 3/8" aluminum hull. The hard chines had to be re-welded frequently because of cracking on the sharp seams. The chines were softened in the new hull to help reduce this problem. A Tarset coating, heavily waxed, has replaced the ineffective "steel flex" coating.

The uncovered deck and exposed transverse frames also created problems. Bilge water sloshed around in the bottom of the boat and the framing presented a tripping hazard. Plywood deck plates were installed to alleviate this problem. A survivors cabin was constructed in the bow area of the boat (Figures 3.9 and 3.10). This cabin is provided with two small fan heaters which provide a measure of protection to survivors. The cabin can be entered by means of two aluminum, hinged covers or by means of an after, canvas, flap door. Two wooden storage boxes have been placed in the waist area of the airboat (Figure 3.11) and a "T" rail has been added for crew safety.

Lighting for CG-184149 is provided by two, white, aircraft landing lights and two forward fog lights. The boat is also equipped with a

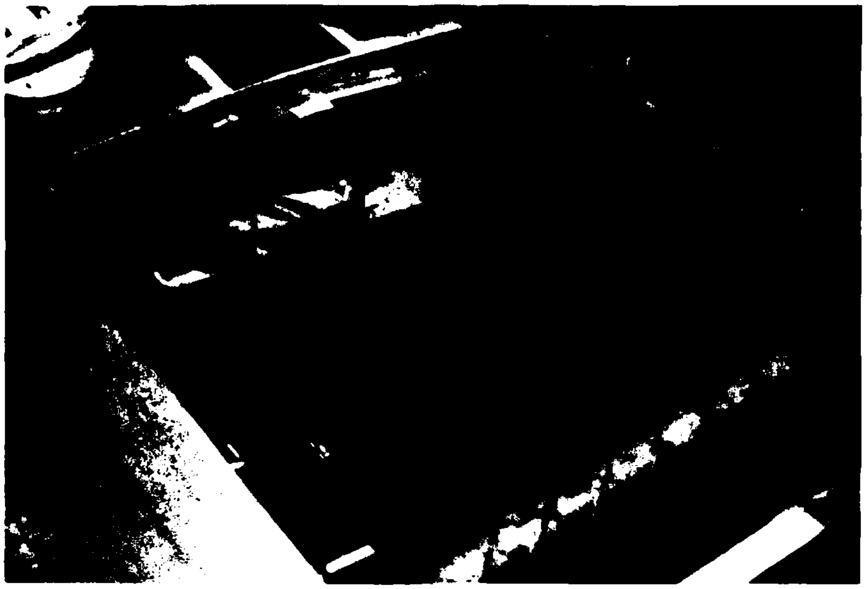


Figure 3.9 The interior of the survivor's compartment, shown with covers open.

Figure 3.10 The survivor's compartment is equipped with two, small, electric heaters.

Figure 3.11 Starboard side, wooden storage box.

rotating blue light mounted atop the propeller cage. Communications is via a VHF-FM, Triton radio and aircraft helmet. The helmet is absolutely necessary due to operating noise. Communication between crew members is by simple hand signals worked out and standardized by the crew. This method seems to work effectively.

The craft can be launched directly from the station or trailered to the launch site nearest the distress call. It is capable of making an easy transition from ice to water, and vice versa, and is not harmed by a breakthrough. According to the Officer-in-Charge, Coast Guard Station Saginaw River, the craft has been operated in excess of 50 mph on unobstructed ice and responds very quickly in adverse conditions.

The normal crew consists of three men - a coxswain, engineer, and crewman. While the coxswain pilots the boat, the two crew members act as lookouts and help to direct the craft by means of hand signals. Victims can be placed in the survivor's compartment immediately upon recovery. Figure 3.12 is a complete list of equipment carried by CG-184149. The crew at Station Saginaw River seems to have evolved an effective method of operation.

Figure 3.12

Airboat Equipment List CG-184149

Forward

3 Blankets
3 Bailey S. S.
1 Wet Suit with Parka
3 Flotation Bags

CABIN

1 Comco
1 CB Radio
1 Heater from Engine
1 Battle Lantern
1 First Aid Kit

PORT SIDE DECK BOX

Various Size Line
1 Anchor with Line

1 Portable Heater, Catalytic
1 Ambu Bag and 3 Space Blankets
1 Heaving Line
1 Bull Horn
1 Power Horn
2 Ensigns
1 Life Ring
1 Line Throwing Gun
2 Five Gallon Gas Cans
2 Pry Chemical Extinquishers
1 CO^2 Extinquisher
1 Boat Hook
1 12 Volt Battery (Spare)

Starboard Side Box

1 four man Life Raft
1 Pry Bar (Ball Bat)
1 Box Food, Coffee Pot

5 quarts of Oil 20 W 40
4 cans dry gas
Fan Belt
1 Gallon of Antifreeze

4 SAR Kit and Pyro Box
1 Binoculars
1 PRL
1 Swimmer's Harness
1 Marlin Line

Charts and Navigator Gear
1 Compass
1 Fire Axe

4.0 Small Air Cushion Vehicle (SACV) Trials

As part of its effort to find a suitable ice rescue platform, the Ninth Coast Guard District began to examine the concept of using a Small Air Cushion Vehicle (SACV). The U. S. Coast Guard had previously looked at ACV's for use in Arctic and Antarctic operations (4) and for river and Great Lakes icebreaking (5). Although no ACV's are currently in active Coast Guard service, it was felt that several of the characteristics exhibited by this class of vehicle might make it suitable for search and rescue work during the winter season. The Chief, Search and Rescue Branch, Coast Guard District Nine working through the Chief, Search and Rescue Division of the Office of Operations at Coast Guard Headquarters requested support from the Office of Research and Development in selecting and evaluating a candidate SACV in the fall of 1981.

Several commercially available SACV's were evaluated from literature and discussions with various manufacturers. The craft finally selected for the evaluation was tne SKIMA 4 MK III, manufactured by Pindair Ltd. of England. The principle reason for selecting the SKIMA 4 over other SACV's of similar size and design characteristics was its ready availability. The Aviation and Surface Effects Department of the David W. Taylor Naval Ship Research and Development Center (DTNSRDC) had recently completed an extensive evaluation of a SKIMA 4 MK III sponsored by the Marine Corps Surface Mobility Exploratory Development Program. After reviewing the two reports published by DTNSRDC researcher Michael Gallagher (6,7) and learning of its

availability, the Coast Guard negotiated an indefinite loan of the craft from the U. S. Navy in November 1981.

Coast Guard Group Detroit, Michigan was designated as the site for assembly and initial testing of the craft. This site was selected because of the shop facilities and trained maintenance personnel and location. Group Headquarters is also located at CG Base Detroit, which is an industrial facility located on the Detroit River. The base maintains a number of well equipped, well staffed shops and it was felt that the craft could be completely supported here with minimal disruption of normal group activities. Immediate access to the Detroit River and the close proximity of Lake St. Clair also weighed heavily on the selection of the site.

After the initial testing was completed, the test program called for the craft to be given an operational evaluation for the remainder of the 1982 winter season. Coast Guard Station Toledo, Ohio was selected for this phase of testing. Station Toledo is under the operational control of Group Detroit and is physically located close to the Group Office. This eased the problem of transporting the SACV to Toledo and made it easier to support the craft with technicians from the base. The entire test area is shown in Figure 4.1.

4.1 Description of the PINDAIR-SKIMA 4 MK III

The PINDAIR SKIMA MK III is a sixteen foot, inflatable SACV designed to carry four people. The craft is manufactured and marketed by Pindair Ltd. of

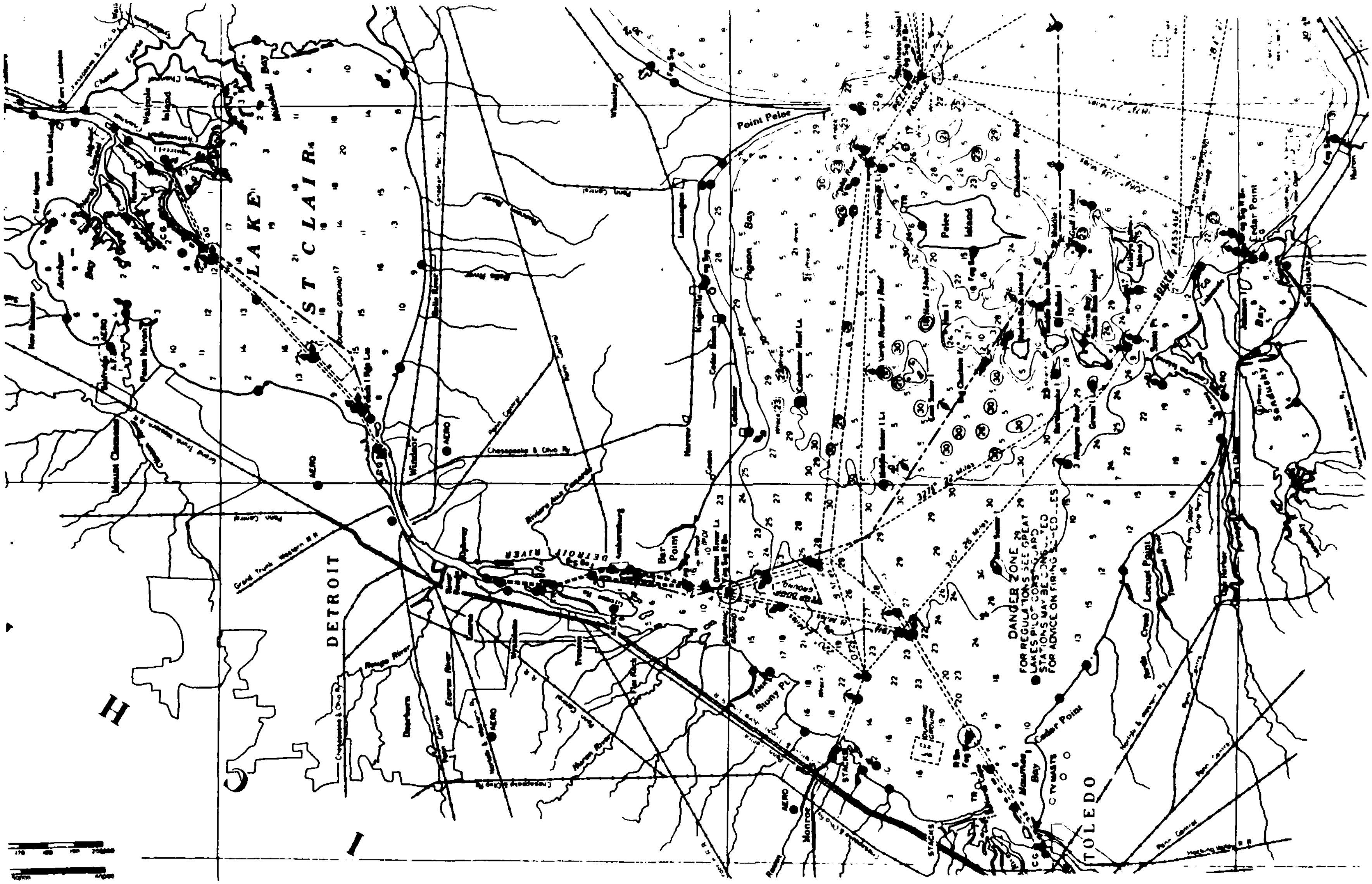


Figure 4.1 Designated testing sites for the SACV included Lake St. Clair, Detroit, Michigan, and Toledo, Ohio.

TECHNICAL DATA

EXTERNAL DIMENSIONS including Skirt

Length	5105 mm	16 ft.	9ins.
Width	2388 mm	7 ft.	10 ins.
Height	1525 mm	5ft.	0ins.

EXTERNAL DIMENSIONS excluding Skirt

Length	5030 mm	16 ft.	6 ins.
Width	2083 mm	6 ft.	10 ins.
Height	1270 mm	4 ft.	2 ins.

INTERNAL DIMENSIONS

Length (incl. bow)	3000 mm	10 ft.	0 ins.
Length (excl. bow)	2000 mm	6 ft.	6 ins.
Width	1000 mm	3 ft.	3 ins.

PACKED DIMENSIONS for Shipping

Length	1585 mm	5ft.	2½ ins.
Width	1270 mm	4 ft.	2 ins.
Height	1335 mm	4 ft.	4½ ins.

WEIGHTS

Unladen weight with minimum equipment	225 kg.	500 lbs.
Unladen operating weight including fuel	250 kg.	550 lbs.
Packed weight including spares kit & crate	350 kg.	770 lbs.

FUEL

Normal Capacity	23 ltrs.	5 gals.
Average Consumption	11 ltr/hr	2½ gal/hr

Fuel Type 25:1 92 Octane Gasolene/Outboard Motor Two stroke Oil

PERFORMANCE

Cruising speed over water	40 km/hr	22 knots
Maximum speed over water	55 km/hr	30 knots
Maximum Payload	300 kg.	660 lbs.
Noise level (at cruise power)	78 DbA	25 m.
Maximum continuous slope unladen	7° or 1:8	
Maximum continuous slope laden	5° or 1:11	
Cushion height	380 mm	15 ins.
Maximum wave height	1.0 m	3 ft.

Great care has been taken to ensure that performance claims, based on trials in the U.K. are not exaggerated.

The SKIMA 4 is designed to conform with the requirements of the Hoverclub of Great Britain.

All particulars are approximate and subject to change without notice

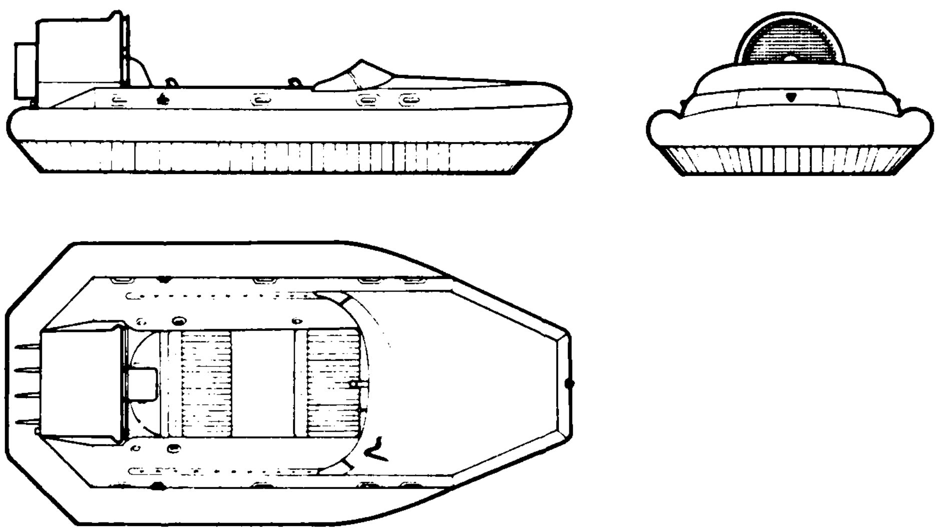


Figure 4.2 The technical data sheet for the Skima 4 MK III obtained from the manufacturer's brochure.

England. Figure 4.2 is the technical data sheet obtained from the manufacturer.

The SKIMA 4 is an inflatable craft with no rigid structural support. The hull is composed of four tubular compartments constructed of a Hypalon/Nylon material. The material is abrasion and puncture resistant, and treated to retard deterioration by exposure to sunlight. The hull is designed to flex to a small degree in rough conditions (manufacturer's information). Four automatic pressure relief valves are incorporated into the tubes at the fill points to prevent overpressurization when filling or during operation in hot weather. The craft has a tapered, but blunted, bow which is covered with the same Hypalon/Nylon material that is used in the tube construction and an integral fabric floor. During assembly, four fiberglass covered, foam panels are fitted into the craft before inflation. These four panels are interlocked by means of aluminum channels, and, when installed, provide a rigid floor for the craft. The bow floor panel is tapered to fill the entire bow section and its leading edge fits into a neoprene/nylon groove. Once this is accomplished, the other three panels are easily inserted and locked in place. There is, however, some separation between the panels during craft operation and it is difficult to take up the slack after the assembly is complete.

The engine/fan assembly is a one piece, preassembled section that slides into the back of the craft and interlocks with the fiberglass floor panels. It consists of the engine; lift-propulsion drive and fan assembly, battery compartment, and one-piece molded, fiberglass cowl.

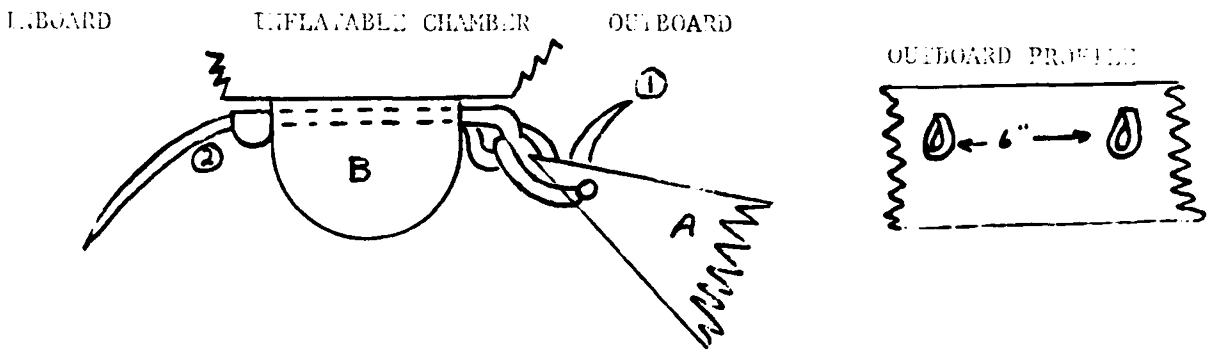


Figure 4.3 Finger attachment is by means of plastic tie strips. #1 is a plastic tie which is attached to the loop made in a second plastic tie, #2, which has been inserted through a hole in the skid pad, B.

The dashboard assembly is constructed of molded fiberglass and has no instrumentation. The steering mechanism/throttle control is a single hand grip assembly - of the motorcycle type - located in the center of the dashboard. To the left of the steering handgrip is an up and down lever which controls the amount of airflow diverted to lift. A thin, wrap around, plexiglass windshield is mounted just forward of the dashboard. The 5 gallon gas tank is mounted under the bow cover in a molded saddle which is integral to the forward flooring section.

The SKIMA 4 utilizes a bag and finger, flexible skirt system designed by the Hoverclub of England (6). The 15 inch neoprene/nylon bag encloses the entire system and is attached to a lip running around the hull of the craft. Attachment is by nylon cord lacing. Each of the 100 finger segments is attached to the lower edge of the bag by means of nylon screws and nuts. The tips of each finger are attached to the underside of the craft by plastic tie strips (Figure 4.3 and 4.4). The forward fingers, from the turn of the tapered bow to the blunt nose, are attached underneath to a V-shaped panel (Figure 4.5). This retains the uniform contour of the fingers and helps to keep the craft in a nose up attitude. This is important to help overcome the plow-in tendency which is characteristic of ACV's (8). The rear finger attachment is shown in the drawing in Figure 4.6. This arrangement prevents the stern fingers from digging in during forward motion and creates a plenum chamber for the craft.

Figure 4.4 The end of each finger is attached to the rub rail by means of a plastic tie strip.

Figure 4.5 A photograph of the underside of the ACV showing the U-shaped panel and forward finger attachments.

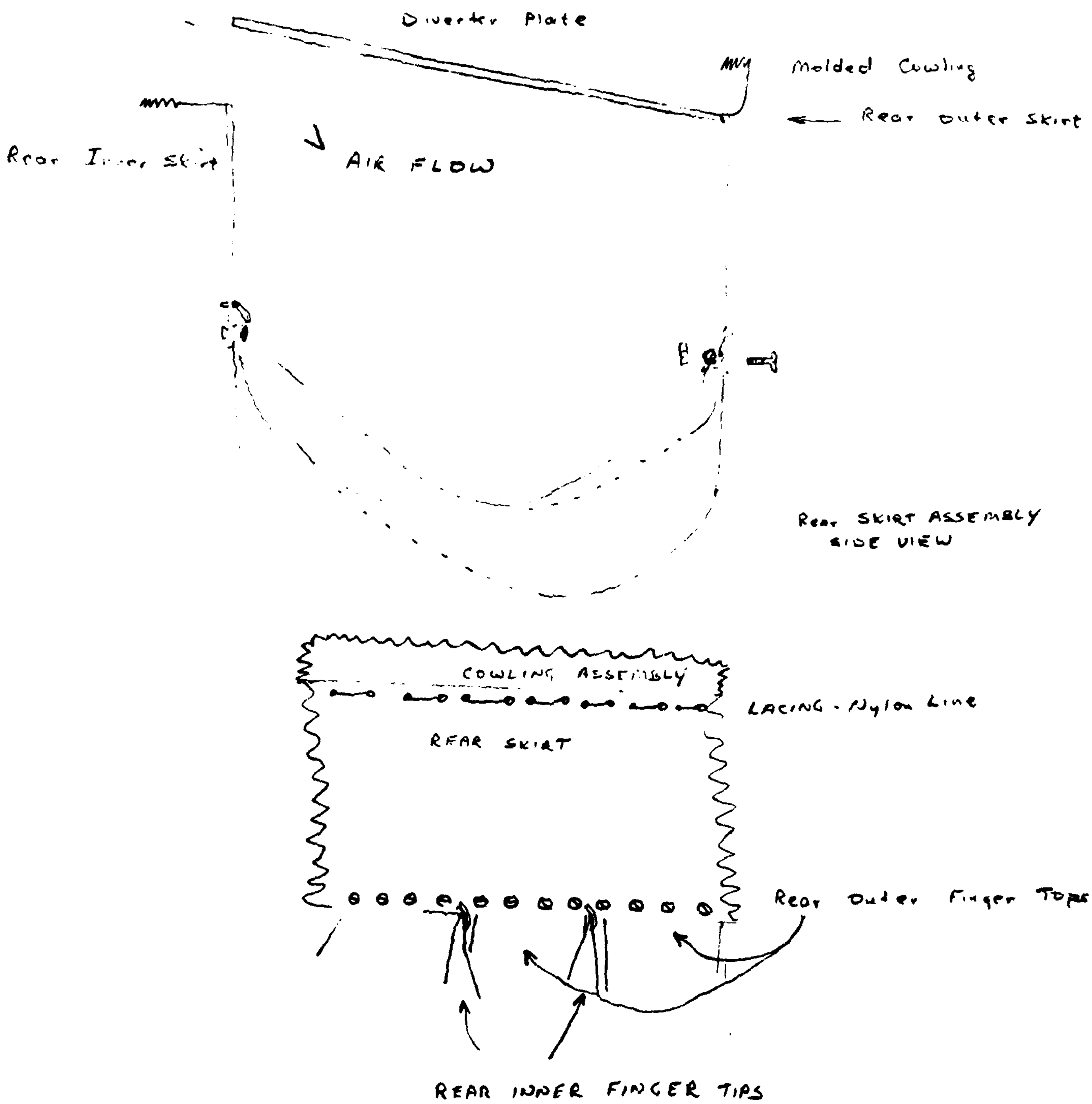


Figure 4.6 Rear Skirt attachment

The medium weight neoprene/nylon skirt material is extremely durable and seldom damaged. There is a further protection for the fingers built into the system by a weak link design. The nylon screws and plastic tie straps are designed to break away first, reducing the possibility of finger tear. This creates a problem for an operational craft. During the testing of the SACV, approximately one hour was spent in examining the skirt system and replacing screws and twist ties for every hour of operation. This is an unacceptably high maintenance to operation ratio. The sternmost eight segments on both the port and starboard sides showed the greatest tendency to break nylon screws. It was felt that this problem could be overcome if stronger fasteners were used. For the final ice trial, the last four finger segments on the portside were fastened to the bag with stainless steel pop rivets and the next four, going forward, were attached with 6-32x3/8 inch (rounded head) stainless steel screws and 3/8 inch stainless steel washers and hex nuts. Although the craft sustained heavy damage during the final day's trial on Lake St. Clair, these eight segments held. There was no damage to either the fingers or the bag adjacent to the segments.

The craft, as manufactured and received from the Navy, was powered by a Hirth Model 276R snowmobile engine. This model is a 2-cycle, air cooled, 440CC, twin cylinder engine which develops 40 h.p. at 7000 r.p.m. The manufacturer recommends a 25:1 oil mixture. It was found by trial and error that engine performance is greatly improved if a gasoline/outboard motor oil mixture of 32:1 was used.

Naval researchers had recommended (6) that the SACV be outfitted with a more rugged and powerful engine. It was determined early in the tests at Detroit that this would be necessary if large payloads were to be carried for extended periods of time. A Hirth Model F20 engine was purchased locally for installation in the SACV. The F20 is an air cooled, 2-cycle, 650 CC engine with dual intake and exhaust, electric and backup pull start, and CDI dual ignition. The F20 is rated at 55 h.p. at 6750 r.p.m. According to the manufactures representative, the engine when completely installed would develop approximately 60-62 h.p.

Engine installation presented some difficulties. The F20 has a half-inch longer bolt pattern than the 276R. The engine is also taller, with wider heads and would not slide aft far enough into the blade assembly mounting bracket (Figure 4.7). The problem was overcome by welding 4 inch extensions to the sides and floor of the mounting plate (Figure 4.8) and fabricating a 2 1/2 inch extension to the shaft to allow it to mate with the belt drive. The extension, shown in-line in Figure 4.9, was fabricated from 2 inch stock 6012 high tensile aluminum. The drive mounting bracket had to be shaved slightly to allow clearance for the carburetors. A Y-exhaust manifold was fabricated and connected to the engine through the cowling exhaust pipe with a flexible, 18x2 inch galvanzied, strip steel hose. The entire assembly was then lagged for safety reasons (Figure 4.10). A dual carburetor throttle linkage was fabricated by a local motorcycle shop to allow control from the twist grip throttle (Figure 4.11).

Figure 4.7 The blade assembly mounting bracket.

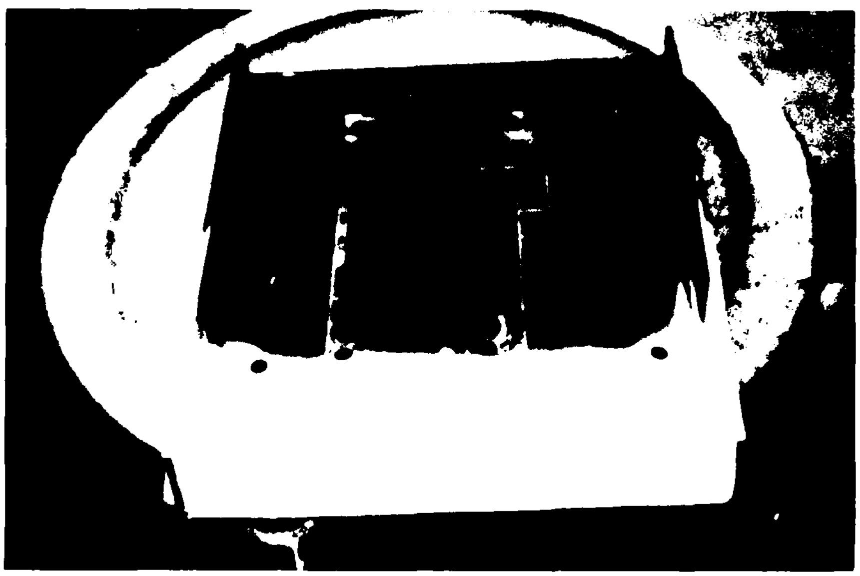


Figure 4.8 Four inch extensions were welded to the bottom and sides of the engine mounting plate.

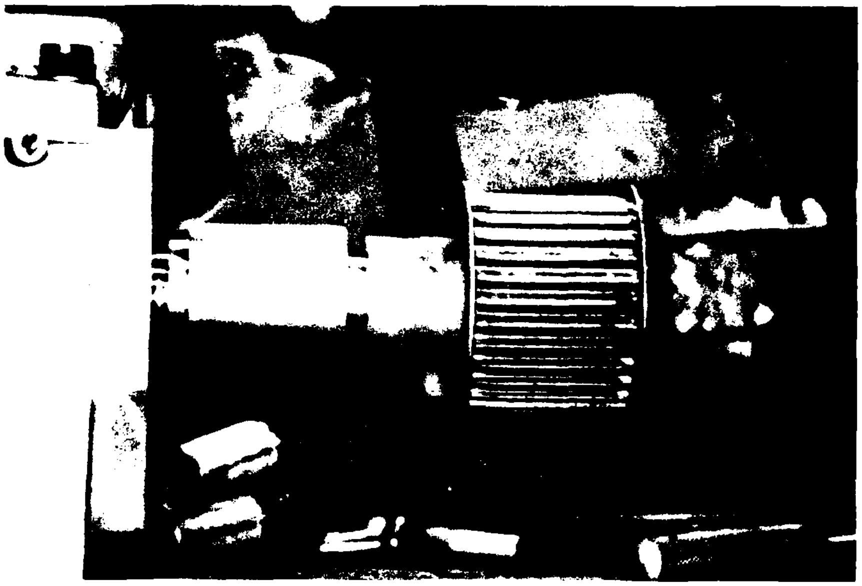


Figure 4.9 The 2 1/2 inch aluminum shaft extension is shown in-line in the above photograph.

Figure 4.10 The Y-exhaust manifold and lagged, strip-steel exhaust pipe.

The SKIMA 4 MK III has an integrated lift and propulsion system. There is a single axial fan mounted in a fiberglass duct unit. The fan assembly consists of a pressed steel hub and six fixed pitch blades (Figure 4.12). The blades are made of polypropylene and are easily changed. The fan is driven by a 50 mm toothed belt and pulley assembly at a 1:3 ratio. Throughout the test, the craft was operated with damaged blades. Spares had been ordered from Pindair Ltd along with a 12 blade hub for the new engine, but they were held up by U. S. Customs and did not arrive in time to be fitted to the craft.

Lift air is diverted to the underside of the craft by means of a splitter board (Figure 4.6). Ten to thirty-five percent of the fan output can be diverted to lift by operating the lever on the dashboard. In the extreme vertical position, 35% of the air is diverted for lift. The splitter board control linkage caused some problems during the test. Within minutes of beginning an operation, the splitter board would lock in position and could not be moved. A thorough inspection of the entire assembly revealed no mechanical problems. Approximately 1/2 hour to 45 minutes after returning to the heated shop, the splitter plate would become operational. It was determined that operating in the frigid, moist air was causing the linkage beneath the plate to freeze. The problem was corrected by installing a rubber boot around the assembly (Figure 4.13). A control cable boot kit, A301143, manufactured by Morse Controls was used.

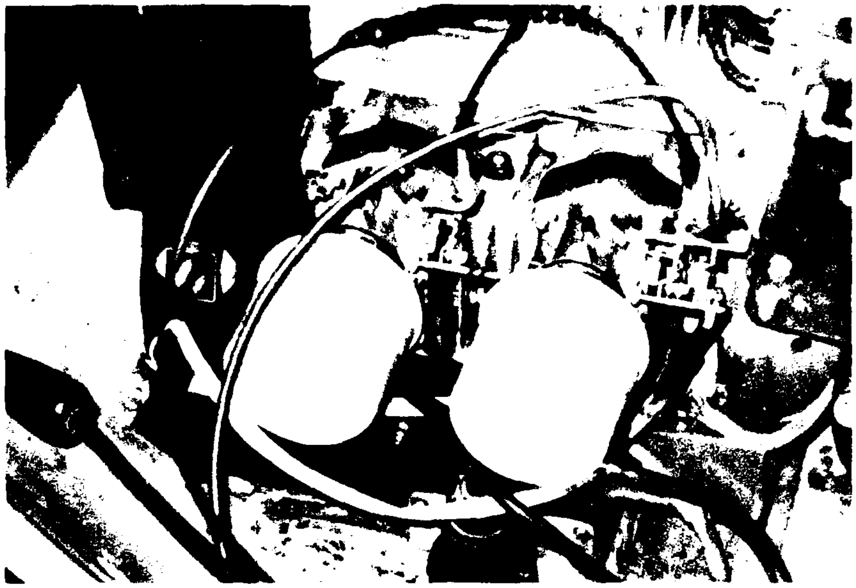


Figure 4.11 Dual carburetor throttle linkage fabricated to allow synchronized operation from the single twist grip throttle control.

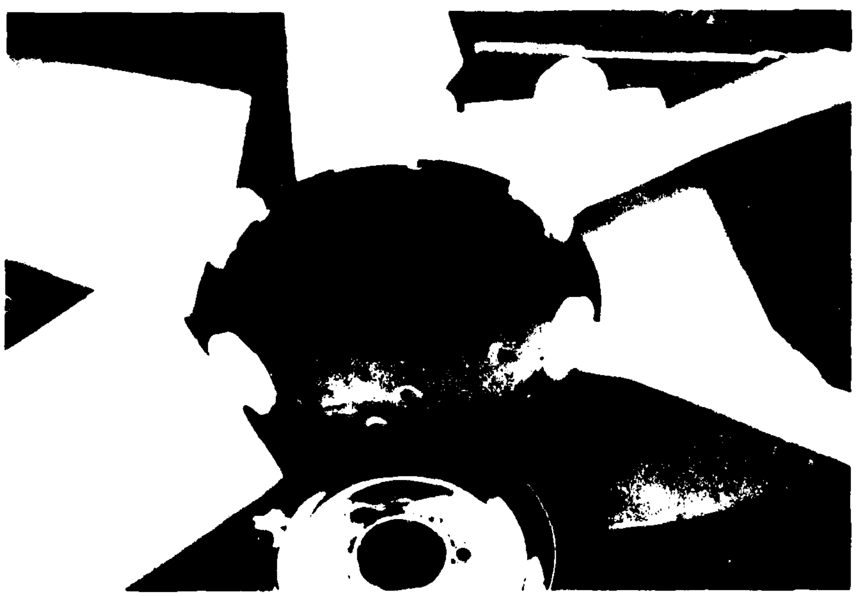


Figure 4.12 The pressed steel hub showing the placement of the fixed pitch, polypropylene blades.

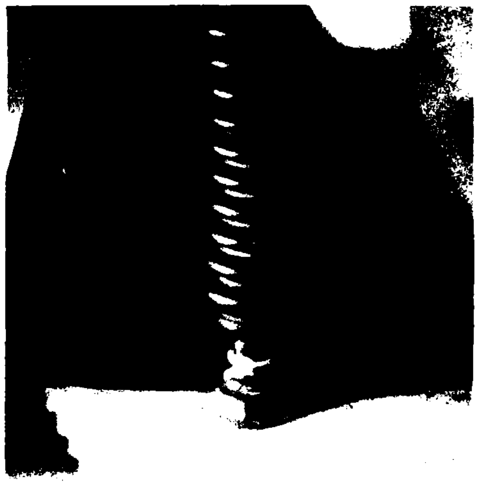


Figure 4.13 A rubber boot was installed around the splitter plate linkage to prevent freeze-up during winter operations.

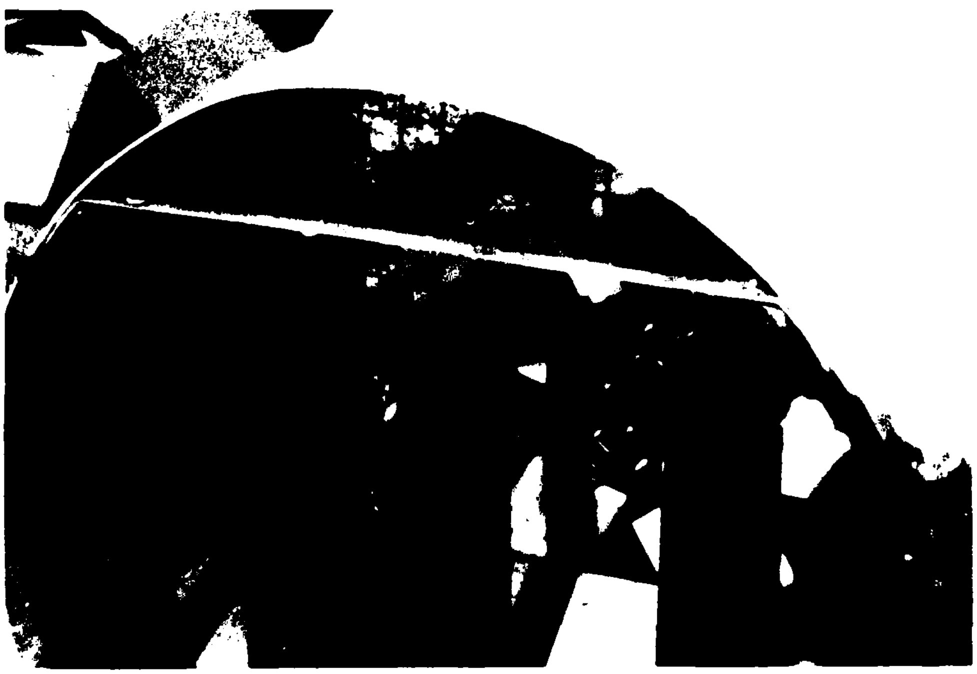


Figure 4.14 Four rudders are mounted in the propulsion duct assembly, immediately aft of the fan.

The SACV is controlled by four rudders mounted in the propulsion duct outlet, immediately aft of the fan (Figure 4.14). All of these are operated simultaneously by a push pull cable attached to a tiller located in the center of the dashboard. In this particular craft, the seats are not installed. The coxswain kneels on the front seat which is simply laid across the deck. The crewmember kneels behind him on the centerline if the craft. The turning rate of the craft can be greatly increased with both men leaning into the turn.

4.2 Preliminary Tests of the SACV

Trials of the SACV were held on three separate days in January of 1982. Following each of the first two trials, modification of the craft was attempted to improve its performance. The third trial, held on Lake St. Clair, ended in a determination to halt all further testing.

The SKIMA 4 was uncrated and assembled in the MK shop at Coast Guard Base Detroit on 4 January 1982. Assembly is not difficult when the instructions are followed. The craft was made ready to operate in approximately four hours. Part of the elapsed time was due to a problem with engine wiring and a bad solenoid. Time was lost in attempting to trace the problems. The only problem never satisfactorily cleared up was the instruction to fasten the inner fabric flaps to the engine/fan/duct assembly. This item, C.37 on page C4 of the instructions, was never done because after following the instructions to this point, no inner flaps could be found that needed

fastening. It is assumed that this item was originally completed by the Navy and never disassembled for shipment. A call was made to DTNSRDC but no one there could remember fastening the flaps or even which flaps were being referred to. The instruction was ignored with no apparent negative effects. In general, however, the instructions are clear and easy to follow.

The initial test of the SACV was conducted in the afternoon on 3 January 1982 at Base Detroit. The base has two slips: the southern slip, occupied by CGC BRISTOL BAY; and the northern slip which was empty. The SACV was hoisted over the BRISTOL BAY by ship's personnel using the ship's crane and lowered into the south slip. It was then driven around the pier into the north slip. Current was running at approximately three knots in the Detroit River at the time. The SACV was held in close to the pier and had no trouble running the approximately twenty yards around the BRISTOL BAY and the pier into the north slip.

The slip presented a sheltered area in which to begin testing the craft. Thin sheets of broken ice floated freely on the surface, with the largest being about 4x16 feet-approximately the size of the SACV. The water was near the freezing point and the air temperature in the mid twenties.

The SACV was driven in small oval patterns twenty to thirty yards long. The craft was sluggish, and although only two men and minimal equipment (hand held radio, etc.) were carried, it was difficult to reach speeds of even fifteen or twenty miles an hour. The most severe problem encountered was

icing. A large amount of spray, consisting of water and ice spicules, was constantly being thrown over the sides and the bow. Within five minutes after operations were begun, the entire craft and both occupants were completely covered with a thin sheet of ice. All surfaces were ice coated, including fan blades, control surfaces, deck, engine, etc. This could, and probably does, account for the sluggishness of the craft. Although both crewmen were wearing wet suits, the situation would have been intolerable on any actual operation. Operations were suspended after half an hour.

The SACV was lifted from the water by the BRISTOL BAY and examined for skirt damage. One portside and seven starboard fingers had become detached, the plastic twist ties having broken.

Following the initial experience with the craft, it was taken back into the shop for repair of the skirt system and engine adjustment. It was decided to lean the fuel oil mixture to 32:1. Texaco outboard and 2-Cycle engine oil-SAE 40 grade prediluted to SAE 20 - and 87 octane regular, leaded gas were used for all tests. After running the engine in the shop, it was felt that this leaner mixture resulted in smoother more efficient operation.

The second trial of the SKIMA 4 was held on 7 January 1982. The SACV was trailered to Selfridge Air National Guard Base (SANG) north of Detroit. The craft was launched from an old seaplane ramp (Figure 4.15) into Anchor Bay, Lake St. Clair. The bay was frozen as far as could be seen from the ramp. The ice was smooth with a light dusting of snow. The air temperature was

Figure 4.15 The old seaplane launching ramp site at Selfridge Air National Guard Base. The extent of ice coverage on Anchor Bay, Lake St. Clair, is shown in the photograph.

$22^{o}F$ with the wind out of the north - northwest at 8-10 m.p.h. The winds had been gusting up to 35 mph earlier in the day but no gusts of over 16 mph were observed during the test. Visibility was good, with hazy sunshine and scattered thin clouds.

The SACV was initially operated with two men to determine if the engine was operating satisfactorily. The craft was run at various throttle settings with the splitter board set to the full open position. Five minutes into the test, the pilot attempted to adjust the splitter board setting and found that it was frozen in the full open position. The craft had to be operated in this condition for the remainder of the day.

The SACV operated smoothly on the ice with two men aboard, the radar gun, brought to check the speed of the craft, would not operate after a few minutes exposure to the cold; but the estimated speed in a quarter mile, straight run was thirty to thirty-five miles per hour. The SACV responded well to the controls and there was no difficulty keeping the nose straight in line with the direction of travel. While turning, only minimal adjustments of the tiller are needed, along with slight body movements. The sharpness of a turn can be controlled by the pilot leaning into the turn; however, the SACV does sideslip considerably in a turn. The crewmember, kneeling upright behind the pilot, should take his cue from the pilot and only lean into the turn when told to do so. After a few minutes, two men can become proficient as a team and handle the craft on smooth ice easily.

A helicopter from Coast Guard Air Station Detroit arrived to take pictures and hovered over the ice at approximately 100 feet. The SACV was able to drive through the prop wash near beneath the helicopter. The craft moves fairly easily into stiff winds when crabbed slightly into the wind.

When dropped off cushion suddenly the SACV will slide for a considerable distance on smooth ice. The distance is, proportional to the on-cushion speed of advance. This can be useful in maneuvering the craft. A helmet was blown off of one of the crewmembers to a distance of approximately 1/4 mile by the helicopter prop wash. The bow of the SACV was easily stopped within one foot of the helmet during recovery. Accurate stops can be achieved from full speed by dropping the craft off cushion to the glare ice, then alternately raising and lowering it with short bursts of power. Each time the craft is lowered to the ice it loses speed and the periodic lifting prevents the SACV from going into an uncontrolled skid. The SACV can be brought to an accurate stop in 20 yards from an approximate speed of 20 miles per hour. This could be extremely hard on the skirt system on anything but glare ice and is not recommended in rougher conditions unless absolutely necessary.

Full speed "crash" stops are not possible on the ice. The quickest way to stop the SACV is to pirouette through 180° letting the fan thrust act as a break. At 30 mph, this takes approximately 40 yards with only two men in the craft. The stopping distance appears to be directly proportional to forward speed and the load condition of the SACV.

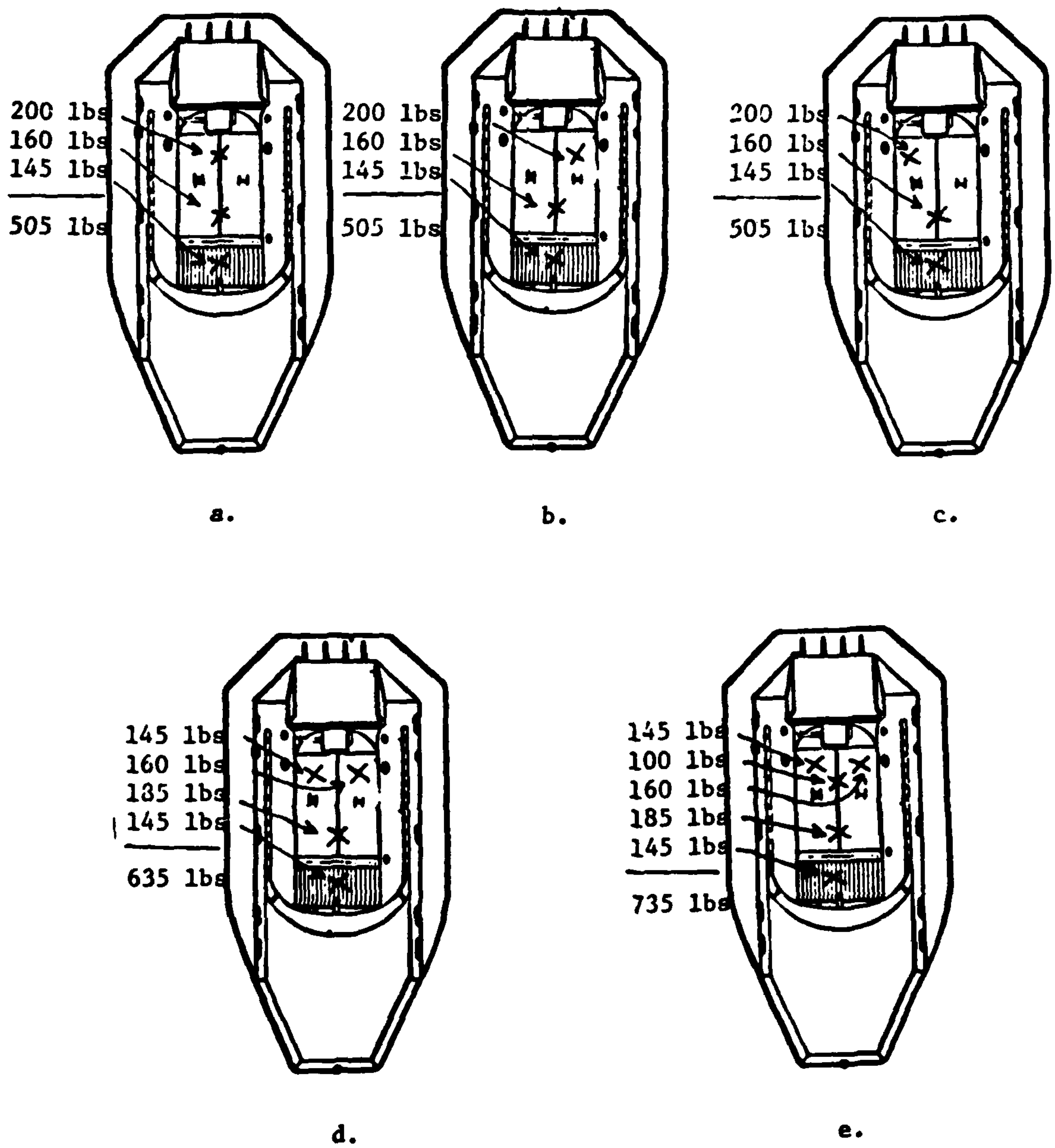


Figure 4.16 Weight arrangements for the loading trials at Selfridge Air National Guard Base.

Three crewmen from Coast Guard Station Toledo, Ohio were each given familiarization rides and then allowed to pilot the craft. They could pilot the craft fairly proficiently on the clear ice after a few minutes operating time. The SKIMA 4 is designed for easy handling and is both responsive and forgiving to inexperienced operators.

A number of loading trials were conducted to see whether or not load placement is critical for ice operations. Two, 100 lb. sinkers were used for the trial in addition to the two crewmen (combined weight 305 lbs.). Runs were made with the weights arranged as shown in Figure 4.16 a, b, c. The craft was run out onto the ice and put through tight turns, crash stops, and full speed runs. No difference was noted in craft handling. Acceleration and stopping is slower when heavily loaded but a top speed reduction was not noticed. Two additional runs were made using crewmembers from Toledo (Figures 4.16 d, e). At a total crew weight of 735 lbs., the results were similar to those noted above for the first three runs; however, occasionally, following a stop, a crewmember would have to get out on the ice to pull on the painter before the SACV would develop any forward motion. Once moving, the craft would accelerate slowly but it could be operated effectively in this manner. The weights shown do not reflect the weight of the fuel, oars, battery, or radio.

Testing was suspended after the throttle cable parted at the hand grip. It was repaired on the ice but due to the condition of the cable end, it was determined that no further operations should be attempted. It should be

pointed out that the cable was known to be old and the parting was not unexpected. An examination of the craft showed that numerous skirt segments were detached. This occurred during the first few minutes of the test when the craft slid sideways across the raised lip of an ice plate.

Following the test at SANG, the decision was made to re-engine the SACV. The 40 h.p. engine was not considered powerful enough and had not run completely satisfactorily since the test began. The modifications discussed in Section 4.1 were made and a final test was scheduled for 20 January 1982.

The SACV was carried out into Lake St. Clair channel on the stern of CGC BRISTOL BAY. The ice had been broken in the channel and refrozen (Figure 4.17). There was a thin dusting of snow over jagged ice plates. Where the plates had been pressed together and refrozen, there were sharp ice edges from 2 to 8 inches high. The ice was approximately six inches thick.

On the first run with three persons aboard, the craft could be felt to hit occasional higher ice lips. With two persons aboard, a sharp full speed turn was initiated with both pilot and crewmember leaning into the turn. The craft banked allowing the starboard skid rail to contact the ice. The rail was peeled back approximately half of its length from its forward attachment point. It is felt that the initial bumping of the ice ridges began to loosen the rail and during the turn it caught on the ice and was pulled free. This effectively eliminated the starboard skirt system. Without it, speeds of no more than 5-7 mph could be attained. The SACV was driven back to the BRISTOL

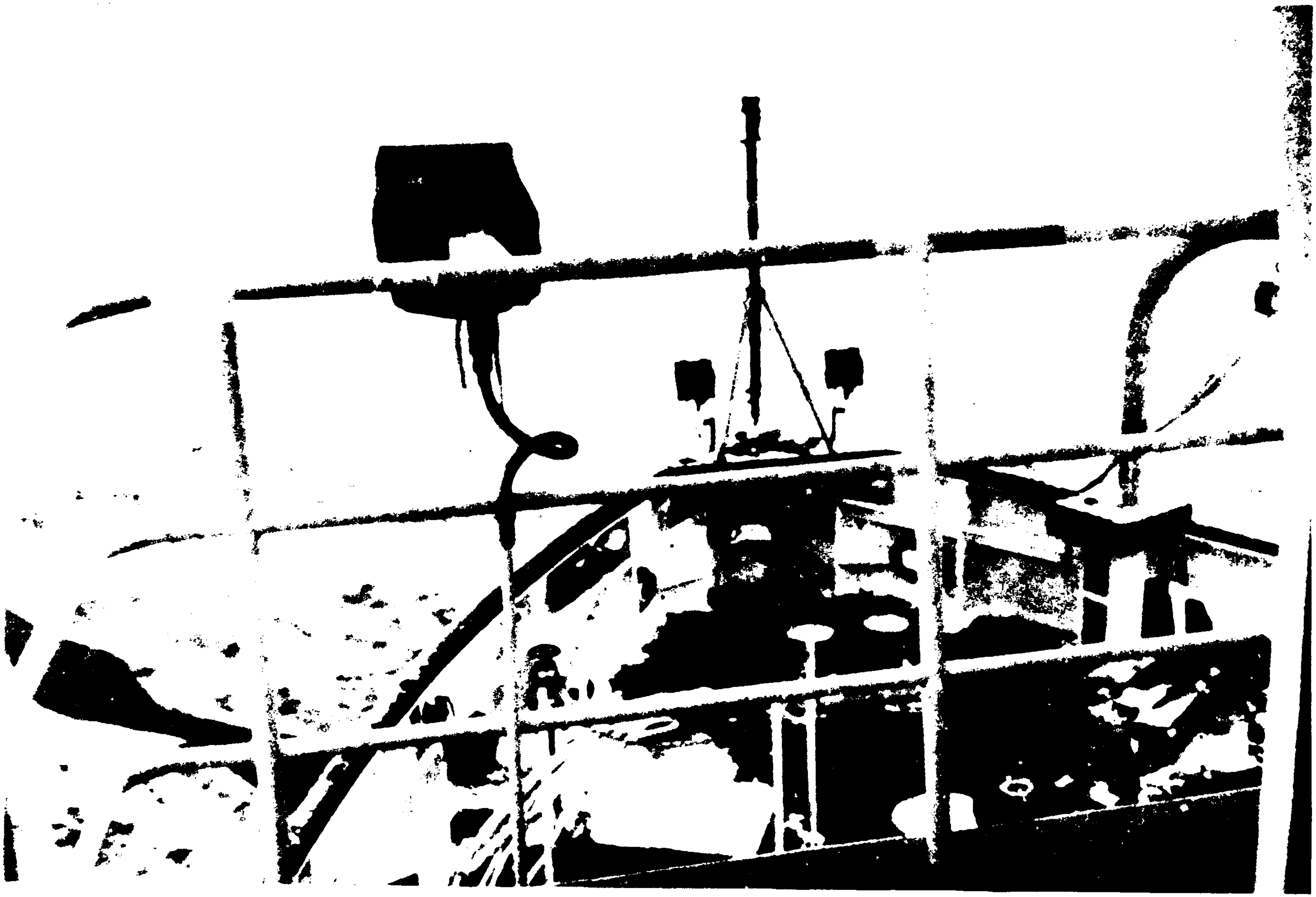


Figure 4.17 A view of the frozen channel in lake St. Clair, taken from the pilothouse of the USCGC BRISTOL BAY.

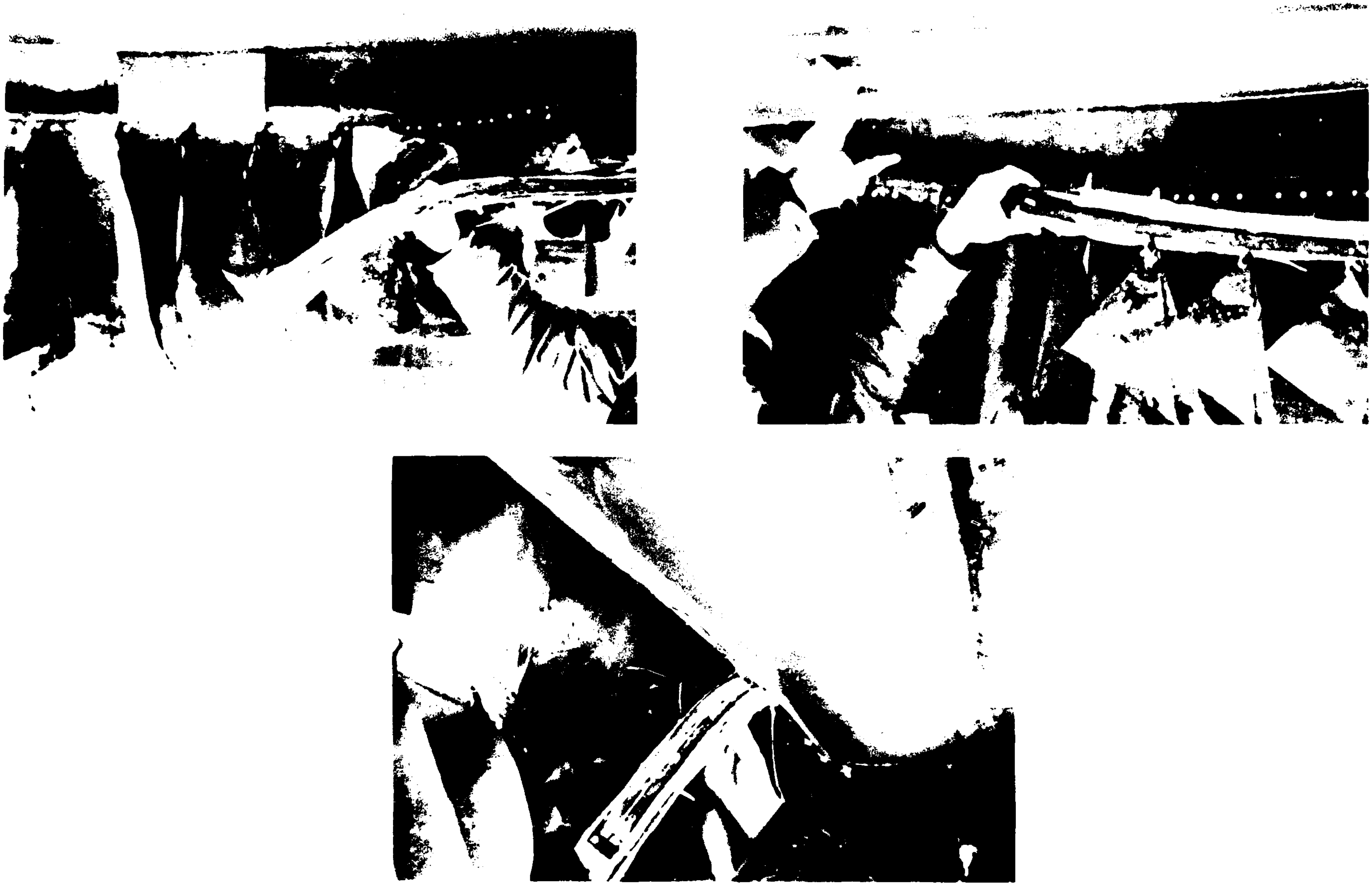


Figure 4.18 Three views of the damaged starboard skirt system.

BAY and hoisted to examine the undercarriage. Figure 4.18 shows three views of the damaged starboard skirt system. Figure 4.19 is a photograph of the port skid rail showing the forward most three feet. The rail was shredded into long thin strips for the first eight to ten inches. Most of the forward plastic ties were also broken. The loose finger segments can be seen hanging free in the background. Only one finger segment was actually torn, sustaining an approximately three inch tear on the leading edge. The V-shaped forward panel and the after panels were not damaged although the finger segments separated when the plastic tie strips failed (Figure 4.20).

This put an end to testing the SACV. All damage occurred within ten minutes of starting the test.

4.3 Conclusions

The decision was made not to include the SACV in the side-by-side trials in Marblehead, Ohio. This decision was based on the results of the Detroit tests and several other factors which became apparent during preparation for the tests.

Any vehicle chosen to be the ice rescue platform used by the Coast Guard must be durable. It is felt that the skirt system of the SACV was too susceptible to damage. Even when operating on flat ice, finger segments become detached easily and a large amount of time must be spent retying finger ends and replacing screws and nuts. The pressure ridges offer far greater obstacles than were encountered on Lake St. Clair and extensive damage to the skirt system is likely if an attempt is made to cross wind rows.

Figure 4.19 The forward 8-10 inches of the port skid rail was shredded by the sharp ice surfaces.

Figure 4.20 The U-shaped forward, under panel was not damaged, although the finger segments separated when the plastic tie strips failed.

The SACV is limited in its ability to climb over obstacles. The maximum ladden slope that can be negotiated is 1:11 (or 5^{o}). This is the same restriction found to apply to the SK-5 ACV tested in the Arctic ice pack in 1970 (4). Vehicle momentum is necessary to cross rough terrain and to climb hills (6). Due to the narrow corridors and short reaches within the windrows, this restriction becomes critical. The craft is not capable of making tight turns at speed due to sideslipping. This also makes maneuvering in the windrows difficult.

The spray problem also presents difficulties. The crew and survivors need to be protected from the elements as much as possible. All ACV's are weight critical and it is felt that the SACV's could not be modified sufficiently to overcome this problem without seriously detracting from performance.

Size is also a problem. The SKIMA 4 MK III has only 39x41 inches of usable space. This becomes crowded very quickly. Unlike the ATV, the SACV cannot tow another craft or skiff to compensate for this shortcoming. Larger, enclosed ACV's are available; however, these are not deemed cost effective. ACV's were not considered as replacements for in-service craft and, consequently, would be utilized for only two to three months out of the year. During this period, their actual operating time would be minimal; therefore, optimization of cost and vehicle characteristics is essential. Therefore, limitation of further testing to the ATV and the airboat was deemed appropriate.

5.0 Airboat and ATV Side-by-Side Trials

As part of their evaluation of the candidate ice rescue platforms, officials in the Ninth Coast Guard District requested that side-by-side trials of the three vehicles be held. These trials were to be primarily a subjective evaluation. Each craft was to be observed as it performed a simulated rescue mission. It was desirable that the craft involved be required to transit as many of the different environments normally seen on a rescue mission as possible. These environments included flat, unobstructed ice; windrows up to four feet, if available; and open water.

The test was scheduled to begin on January 26, 1982 at Marblehead, Ohio, with crews from Station Marblehead, Station Saginaw River, and Station Toledo participating. As a result of the preliminary tests held in Detroit, Michigan, the SACV was not included in the side-by-side trials (Section 4.3); and, therefore, the Station Toledo crew did not participate.

5.1 Side-by-Side Test Course Description

A test course was laid out to incorporate as many of the desired conditions as possible. A helicopter survey of Lake Erie conducted early on the morning of the 26th reported no open water in the Marblehead area. Because of this, the open water/ice interface could not be included in the test course, but it was decided that should an opening occur, we would try to

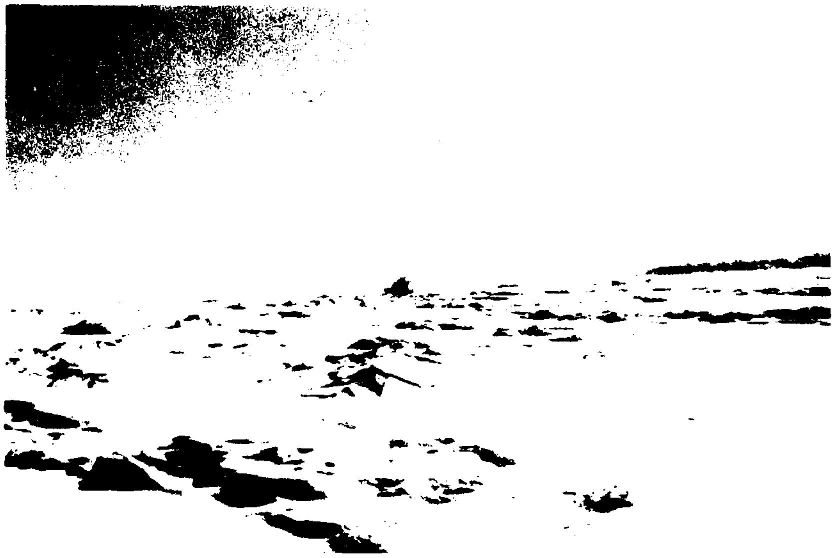


Figure 5.1 (a and b) Two views of the pressure ridges encountered during the side-by-side trials at Marblehead, Ohio.

take advantage of it. The test course was roughly "U" shaped, with its major axis laying parallel to the shoreline.

On the day of the test, a series of windrows approximately 1/8 of a mile deep ran parallel to the shoreline at Station Marblehead. The individual pressure ridges were anywhere from a few inches high to approximately 4 feet high (Figure 5.1a,b). The starting point for the course was the station itself. The first leg ran directly out onto the ice, perpendicular to the windrows, to a pylon set inside the windrows within ten yards of clear ice. The next leg was a straight path westward to a second pylon one mile away. This second leg lay entirely within the windrows. The course made a 90^{o} turn north at the second pylon and ran out onto the clear ice for 1/2 mile. Here, at the third pylon, the course turned eastward and ran back on clear, unobstructed ice for one mile to the pick-up point where a simulated victim was to be picked-up and returned to the station. The test vehicles were required to retrace their paths back to the station. The total course length, from start to finish, was 5 1/4 miles.

Actual testing involved two simulations. The first scenario used only the first two legs of the course and was run entirely in the windrows. The second was run using the entire course. This was done for two reasons. First, it was desirable to observe both craft in operation in the windrows and to videotape each craft as it negotiated these obstacles. Secondly, it was desirable to take some of the competitive edge off of the participants. Due to the skill necessary to operate each craft on the ice, it was decided to restrict crews from the two stations involved to their own familiar

vehicles. This resulted in an unwanted air of competition between personnel from both stations. It was felt that the excessive speed on the clear ice might be avoided if crews had several completed runs behind them before they were given an opportunity to attempt the one mile long stretch on the unobstructed leg. This, in fact, did seem to reduce the "race" atmosphere somewhat.

The crews for each craft were comprised of personnel who would actually be called upon to respond to cases at their respective stations. The driver was changed for each run and each driver was given a questionnaire (Appendix B) to fill out at the end of the run. An EMT qualified, BM1 from Station Marblehead acted as the victim in each case and provided comments concerning the quality of ride for the victim in each craft.

5.2 Results

The actual trials were held on 26 January 1982. During the day's runs, the temperature increased from 16°F to 23°F, with the wind out of the south, increasing from 8 knots to 20 knots. The sky was clear and bright with high scattered clouds. An ice core was taken and measured 14 inches.

An initial briefing for all participants was held at 0900. Following a description of the course and procedure to be followed, the participants moved to their assigned locations. Observers were placed at the starting point, the first two pylons, and the pick-up point. The crews for each

a. The ATV negotiating the windrows.

b. Airboat negotiating the windrows.

Figure 5.2 Both the ATV and the Airboat completed the initial trials without difficulty.

craft were instructed to remain in the station ready room. At the sound of the bell, the crews would then dress in protective clothing, launch their craft, and get underway.

For the first two runs, the ATV did not haul the trailer because it would not normally be utilized in the first scenario. For the first run, the ATV completed the course in 23 minutes and the airboat in 17 minutes. Both craft maneuvered easily in the windrows and completed the course without difficulty for both of the initial runs (Figure 5.2a,b).

For the longer run, utilizing the entire course, an additional constraint was placed on the ATV. It was required to haul the trailer with skiff. Because the ATV is restricted from operating in open water, the crew was required to stop at the pick-up point, unload the ice skiff, then start the outboard motor. The victim was then placed in the skiff, the skiff loaded on the trailer, and then returned to the station. This allowed observers to see this part of the operation even though no open water was present. The ATV completed the first run of the second scenario in 42 minutes. This included a brief stop in the windrows to examine a flat trailer tire. It was decided to continue the run with the flat tire because this would have been the normal procedure in a real case. The time from launch to arrival at the pick-up point was only 19 minutes, even with the flat tire. Figure 5.3 is a photograph of the ATV and trailer underway with the recovered victim. The flat tire is visible in the picture. Because of the flat tire Scenario 2 run was not completed and no times are available.

Figure 5.3 The ATV underway during the trials. The flat tire on the trailer is visible in the picture.

Figure 5.4 The crack in the airboat runner is visible at the seam in the above picture.

The airboat completed its first run of the complete course in 23 minutes. The airboat was visibly pounding in the windrows and suffered some damage to the runners on this run. Figure 5.4 is a photograph of the runners showing the cracking that occurred. During the run back to the station, the simulated victim refused to stay in the survivor compartment because of the pounding ride. For the second run, the speed of the airboat was greatly reduced and the entire run took 61 minutes. No further damage to the craft occurred at this speed, and the victim reported a much smoother, if not entirely comfortable, ride. The victim is visible in Figure 5.5 sitting in the forward section of the airboat with his legs in the survivors compartment. The airboat occasionally got stuck on top of a windrow and a crewmen was required to get out and rock the craft over the hump (also visible in Figure 5.5).

Following the last run of the airboat, open water was reported about 1/4 mile off Marblehead light. It was decided to proceed to the site and, if possible, observe and videotape both craft transiting the open water/ice interface. At the time of arrival at the open water, the wind was estimated to be blowing out of the south at approximately 25 knots. This created a potentially severe cross wind for the craft as they made the transition. CO Station Marblehead, acting as test safety officer, declined to launch the ATV for safety reasons. The airboat was launched and had no difficulty making the transition from ice to water and vice versa. Observers riding in the airboat, however, reported a noticeable spray coming into the craft while operating in the light chop.

Figure 5.5 A crewman is visible in the picture as he attempts to break the Airboat loose from the ice. The "victim" is seated with his legs in the survivor's compartment, in the forward area of the airboat.

The airboat also demonstrated its capacity to carry survivors, in that during the transit across the open ice to the cut, thirteen people were transported with no noticeable decrease in operating efficiency.

Conclusions and recommendations based on the entire sequence of testing all candidate platforms are presented in the next section.

6.0 Conclusions and Recommendations

The reason for testing the three vehicles described in this report was to determine if any or all of them could be considered as replacements for the current method of hauling an aluminim ice skiff by hand across the ice. Each of the craft was considered a possible candidate platform and it was realized from the beginning that each had both drawbacks and desirable features. None of these craft were originally designed as an ice rescue vehicle and it was realized that allowances would have to be made for features that could be changed in a model specifically ordered for Coast Guard use.

The Air Cushion Vehicle proved to be inadequate for several reasons outlined in Section 4.3. Primary considerations were its susceptibility to skirt damage, its limited payload capability, and its lack of maneuverability (particularly, tightly controlled turns) on the ice. These problems are not considered limited to the vehicle tested but are characteristic of small ACVs. Slightly larger models are available but they are considered too

costly for such a limited roll. In the future, if an expanded roll for small ACVs is defined, the concept should be re-examined.

The all terrain vehicle is a capable craft that is a possible choice for selection as an ice rescue platform. Its main drawbacks are its size (limited capacity for victims), its lack of flotation, and its inability to transit open water and climb out of the water onto the ice. It is possible that these problems can be overcome in a larger model.

The craft handles easily on the ice and is highly maneuverable. It has an open ice speed of 25 m.p.h. and the ability to cross windrows rapidly (10-15 m.p.h) with little difficulty.

The ability to tow a trailer compensates somewhat for its lack of size. The craft when operated singly (without tow) can be used effectively to search a large area safely and quickly. The towed ice skiff can be used to transit open water. During the Marblehead trials, however, three problems associated with this method of operation surfaced. The trailer can become stuck at the top of a pressure ridge necessitating that one of the crew members get out and push it free with a power assist from the ATV. The flat tire is another problem that can be expected to occur when towing the trailer through the windrows. The trailer was not designed for this type of operation and modifications would have to be made to strengthen it. The third problem is associated with the outboard motor. During the first run of Scenario 2, it failed to start. Outboard motors are, by nature,

difficult to start in cold weather. This problem could be expected to occur frequently.

The victim reported that the ride in the skiff was not uncomfortable and it appears that survivors could be effectively transported in this manner. They are, however, still exposed and would have to be carefully wrapped in blankets and protected from the weather as much as possible.

The speed of the ATV is another factor in its favor. It is quick enough to perform its missions yet not fast enough to create problems if driven with caution. A new individual reporting to the station could be trained to operate this craft safely in a short period of time. This is an important point, given the high turnover rate of station personnel.

Vehicle maintenance and operating cost are also minimal as compared with other candidate vehicles. This, plus the low initial vehicle cost ($5,256.45) make it an attractive alternative to the current method of responding to ice calls.

On the basis of tests conducted to this point, the airboat is the most capable of the three vehicles tested. It has the ability to transport large numbers of victims safely while carrying a large equipment inventory (Figure 3.12). The craft can respond quickly in a variety of situations and is not as limited by conditions as are the ACV or ATV.

The airboat, as presently configured, does have some drawbacks that must be considered. First is its speed. The craft has been operated at speeds in excess of 50 m.p.h. on the ice. The necessity of this is questionable. The craft is not capable of crash stopping and must be pirouetted through 180° in the same manner as the ACV. A collision with debris of any kind at such high speeds could have serious consequences. On the first trial of Scenario 2, the airboat slid 210 feet past the victim. This was after the coxswain had been instructed to stop the craft as close to the prone victim as possible. A less experienced coxswain stopped the craft within a few feet of the victim on the next run. This illustrates an important point that must be borne in mind when considering any of these vehicles: the more familiar the operator becomes, the less cautious he is likely to become. All of these craft are inherently fun to operate. This, mixed with the inability of the coxswain to accurately judge speed of advance over ice can lead to problems.

The airboat has a tendency to stick to the ice when stopped. A baseball bat is carried and used as a pry bar to loosen the runners. In addition a large initial thrust is necessary to break the craft free and get underway. For an actual Coast Guard Service Model, a safer powering alternative might be to reduce the pitch of the propeller for a slower forward speed while still providing sufficient initial power to allow the craft to break loose.

Another problem aggravated by speed is hull damage. The craft is subjected to a lot of pounding in the windrows. Slowing the craft down will

reduce the strain on the hull and runners. In Figure 5.4 the crack in the runner is clearly visible. The crack occurred at the weld where two pipe lengths had been joined. The joint is at the forward curve of the bottom of the hull and lies at the point subjected to the maximum stress when crossing the windrows. If possible, the pipe lengths should be adjusted to place the weld further back toward the center of the craft or a single pipe length should be used. This would most probably prevent a re-occurrence of cracks if the craft were to operate at reduced speed in the windrows.

The simulated victim reported that he could not remain in the survivor's cabin while crossing the windrows. He was placed in a Stokes litter and was lying head forward in the compartment. There was only about a 2 inch clearance between his face and the compartment cover. He reported a great deal of pounding on the flat ice and asked to be removed from the compartment before the windrows were encountered. Overhead clearance should be increased and the entire compartment, including the inside of the hatch covers, padded before it is used to transport survivors. Also, speed must be held to a minimum for the victim's safety.

The airboat has no difficulty making the transition between ice and water. This eliminates having to use multiple vehicles to conduct a rescue. The ease with which it negotiates the various types of terrain encountered in ice operations makes it the preferred vehicle. It can also be utilized in the summer months to respond to cases in shallow or backwater areas. This lessens the impact of the initial cost (estimated to be $11,500

for replacement) and the operating and maintenance costs. For these reasons it is recommended that, if only one vehicle is to be selected as the primary ice rescue platform, a production model airboat, built to Coast Guard specifications, should be purchased.

It is also recommended that a rigorous training program be set up and that no person be certified as an airboat coxswain until he has completed the course and demonstrated an ability to operate the craft safely under a variety of conditions. This is felt to be extremely important due to the high performance characteristics of the airboat and the severity of the environment in which it will be operated.

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Appendix A

Do's and Dont's for Operating the ATV.

1. Don't operate the ATV on pavement with studded tires.
2. Don't engage reverse while in forward motion.
3. Don't try to go forward while vehicle is still rolling.
4. Don't operate ATV without helmets.
5. Don't forget to reinstall bilge plugs prior to operating in water.
6. Don't operate reverse to excess because of rapid drain on the battery.
7. Do turn off the key and ensure that the radio is turned off when securing the ATV.
8. Do take care when crossing the windows.
9. Do come to a rolling stop when towing the ice skiff.
10. Do wear exposure suits.
11. Do watch the turning radius when pulling the ice skiff.
12. Do operate the ATV in a slow manner.
13. Do make sure that all water is removed from the bilges.
14. Do keep clear of the winch when it is in operation.
15. Do have observers watch the winch to ensure that the cable doesn't come off of the drum.
16. Do make sure the ATV is tightly secured to the trailer before moving.

<u>Appendix B</u>

TRIAL #______________ CRAFT____________

VICTIM_________________________________

1. DESCRIBE THE MANNER IN WHICH YOU WERE PLACED IN THE CRAFT. ____________

2. WHERE AND HOW WERE YOU PLACED, THAT IS, LYING DOWN AFT, SITTING FORWARD, ETC? ____________

3. DESCRIBE THE RIDE OVER FLAT ICE AND OVER WINDROWS. NOTE SPECIFICALLY SUCH THINGS AS POUNDING, ROLLING IN CRAFT, AMOUNT OF WIND AND EXPOSURE AND ANY OTHER FACTORS YOU THINK MIGHT AFFECT AND INJURE PASSENGERS.____________

Appendix B

COXSWAIN/ENGINEER

1. HOW LONG HAVE YOU BEEN OPERATING THIS CRAFT PRIOR TO TODAY'S TEST?
____

2. DID YOU ENCOUNTER ANY DIFFICULTIES IN THE WINDROWS? DESCRIBE.
____
____
____
____

3. DID YOU ENCOUNTER ANY DIFFICULTIES AFTER LEAVING THE WINDROWS? DESCRIBE.
____
____
____

4. DESCRIBE ANY DIFFICULTIES YOU HAD UNLOADING AND LOADING THE CRAFT ON THE TRAILOR.______________________________
____
____

5. ENGINEER - DESCRIBE ANY MECHANICAL DIFFICULTIES.______________________________
____
____
____

COMMENTS______________________________
____
____

Appendix C

1. Due to minimal navigation capabilities and non-existant environmental protection affored to personnel aboard Surface Ice Rescue Vehicles including ice skiffs, airboats, and ATV's, helicopter continues to be considered primary ice SAR resource within Group Detroit, and will be required for all such cases. The foregoing policy should not preclude the timely dispatch of surface resources in an effort to execute a case in an expeditious and safe manor.

2. The potential hazards to rescue personnel in surface resources dictate the establishment of the following operational restrictions on surface ice rescue personnel.

a) Will normally be launched in the case of a known emergency only and not a reported overdue.

b) Will be launched from a point closest to the actual emergency.

c) Will not be launched when surface visibility is less than one quarter mile.

d) Will not be launched when combination of air temperature and relative wind velocity (including vehicle speed) creates wind chill factor of below minus fifty four (-54) degrees fahrenheit.

3. Deviations from the above restrictions may be waived on a case by case basis only by the SMC.